EAST AFRICA HIGH COMMISSION

EAST AFRICAN AGRICULTURE AND FORESTRY RESEARCH ORGANISATION

(Incorporating the East African Agricultural Research Institute, Amani)

ANNUAL REPORT

1953

Postal Address: P.O. Box 21, Kikuyu, Kenya

PUBLISHED BY AUTHORITY
PRINTED BY ZENITH PRINTING WORKS LTD., NAIROBI

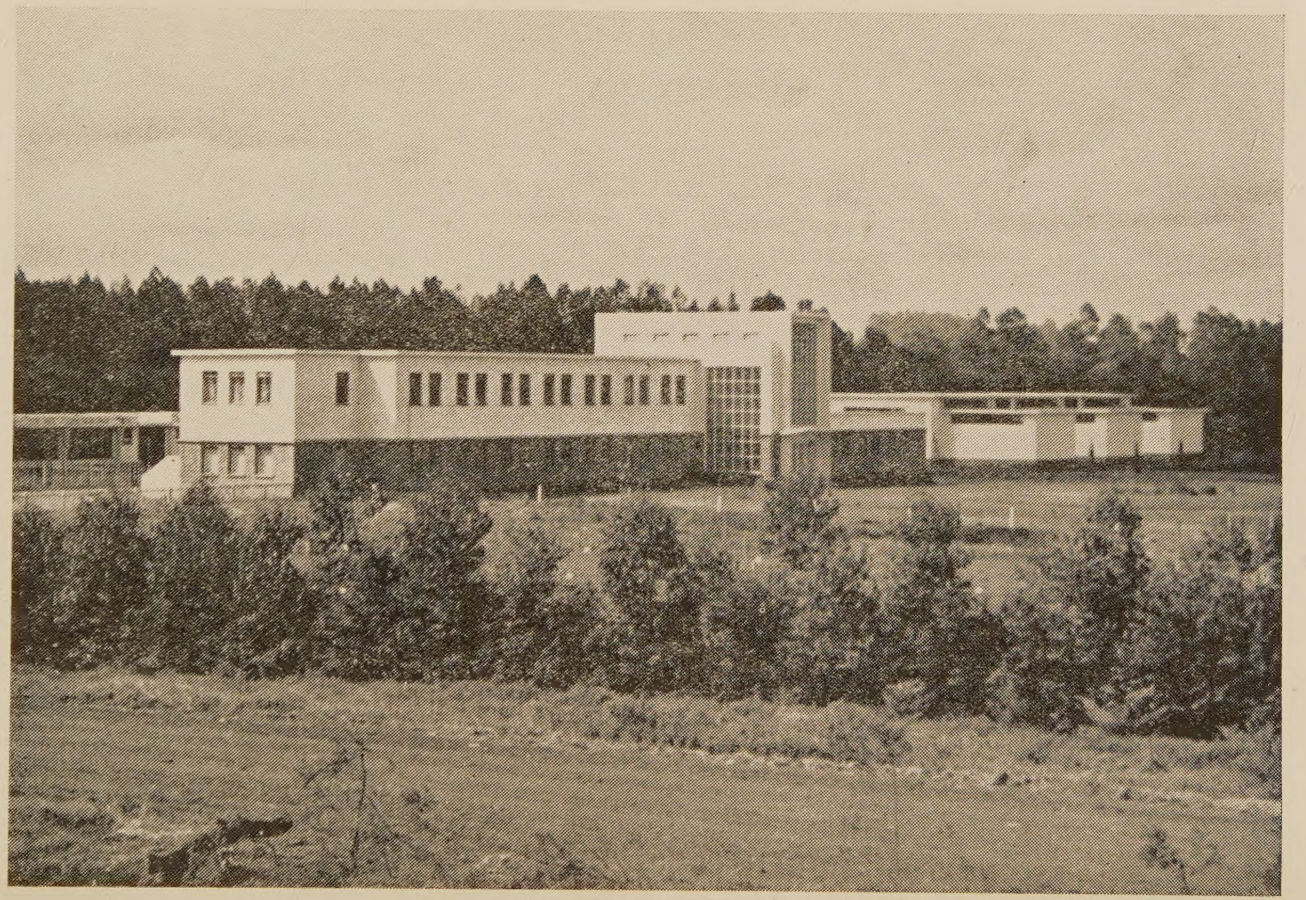

Photo M.T.F.

THE COMBINED HEADQUARTERS AND LIBRARY OF E.A.A.F.R.O. AND E.A.V.R.O. AT MUGUGA, KENYA.

CONTENTS

	Page
Staff List	1
Report by Director	5
Sectional Reports:	
Plant Pathology	19
Plant Breeding and Genetics	24
Crop Insecticides	30
Plant Physiology	32
Forestry	34
Forest Entomology	39
Systematic Botany	41
Soil Microbiology	45
Soil Chemistry	47
Soil Physics	53
Soil Survey	60
Statistics	64
Animal Industry	66
Attached Colonial Development and Welfare Schemes:	
Termite Research	76
Ecological Training	77
Reports by Officers of Overseas Food Corporation	80
Appendices	
Meteorological Observations at Muguga	88
Library	90
List of Publications, 1953	91
E.A. Agricultural Journal Report	94

Digitized by the Internet Archive
in 2025

https://archive.org/details/record-of-research-annual-report-kari_1953

Staff List for the Year 1953

(Including Officers of the Termite and Ecology Schemes)

DIRECTOR

Sir Bernard A. Keen, D.Sc., F. Inst.P., F.R.S.

DEPUTY DIRECTOR

H. H. Storey, C.M.G., M.A., Ph.D., F.R.S.

HEAD OF JOINT ANIMAL INDUSTRY DIVISION

M. H. French, O.B.E., M.A., Ph.D., Dip. Agric.

RESEARCH OFFICERS

H. F. Birch, Ph.D.	*Soil Chemistry*
G. T. Chamberlain	*Spectrochemistry*
L. R. Doughty, B.Sc. (Agric.), N.D.A.	*Plant Breeding and Genetics*
D. W. Duthie, M.A., Ph.D., F.R.I.C.	*Biochemistry* *Editor, E. A. Agricultural Journal*
M. T. Friend, M.Sc., A.R.I.C.	*General Analysis*
J. C. M. Gardner, C.I.E., A.R.C.S., D.I.C., Dip. For.	*Forest Entomology*
J. Glover, M.Sc., M.I. Biol.	*Plant Physiology*
P. J. Greenway, O.B.E., F.L.S.	*Systematic Botany*
A. L. Griffith, O.B.E., M.A., D.Sc.	*Forestry*
P. R. Hesse, Ph.D., A.R.I.C.	*Soil Chemistry*
D. L. Jennings, B.Sc.	*Plant Breeding*
G. H. Gethin Jones, M.Sc.	*Soil Survey*
K. S. McKinlay, B.Sc.	*Entomology*
Miss J. Meiklejohn, D.Sc. *(Seconded from Rothamsted Experimental Station, England. Left August,* 1953.)	*Soil Microbiology*
H. C. Pereira, Ph.D.	*Soil Physics*
P. Robinson, B.A., Dip. Stat.	*Statistics*

R. M. Scott, B.Sc.	*Soil Survey*
Miss F. M. L. Sheffield, D.Sc.	*Cytology*
B. E. St. L. Stuart, B.A.	*Forestry*
B. Verdcourt, B.Sc., F.L.S.	*Systematic Botany*

Scientific Assistants

P. H. Hosegood	*Soil Physics*
Miss M. Maclean, B.Sc. (*Left November,* 1953)	*Spectrochemistry*
W. B. May, F.R.H.S.	*Horticulture*
Mrs. I. B. Pereira	*Animal Industry*
Mrs. A. K. Ryland, B.Sc.	*Plant Pathology*
Count A. E. Starzenski	*Systematic Botany*

Field and Farm Staff

D. W. Gourlay, B.A. (Agric.)	*Field Experimentalist*
H. P. Ledger, N.D.D.	*Farm Manager*
T. Graham	*Field Assistant*
T. E. C. Robins (*Seconded to Agricultural Department, Zanzibar.*)	*Field Assistant*

Administrative Staff

Mrs. M. Doughty	*Clerical Assistant*
Miss V. C. T. Friend, M.A. (*From October,* 1953)	*Clerical Assistant*
Mrs. W. Griffith	*Clerical Assistant*
Mrs. M. May (*From August,* 1953)	*Clerical Assistant*
L. C. Martin, M.B.E.	*Maintenance Superintendent*
A. E. Poole (*From August,* 1953)	*Temporary Superintendent*
Mrs. G. A. Quinion	*Registry Clerk*

Mrs. M. Y. Robinson	*Assistant to Editor, E.A. Agricultural Journal*
Mrs. B. Scott (*Left October,* 1953)	*Clerical Assistant*
Mrs. M. F. Skipper (*Left April,* 1953)	*Clerical Assistant*
Miss M. A. E. Vardy	*Private Secretary to Director*
Mrs. L. Verdcourt, A.L.A.	*Librarian*
S. G. Walter	*Acting Secretary*
A. F. S. Warwick	*Storekeeper*
Mrs. I. M. Warwick	*Clerical Assistant*

UNDER COLONIAL DEVELOPMENT AND WELFARE SCHEMES CONNECTED WITH THE ORGANISATION

W. V. Harris, M.Sc., A.I.C.T.A., M.I. Biol. (*Working at Commonwealth Institute of Entomology, London*)	*Termite Research*
W. A. Sands, B.Sc., A.R.C.S., D.I.C., M.I. Biol.	*Termite Research*
R. M. C. Williams, B.Sc., M.I. Biol. (*From September,* 1953)	*Termite Research*
W. Wilkinson, B.Sc., M.I. Biol. (*From June,* 1953)	*Termite Research*

C. G. Trapnell, O.B.E., B.A.	*Ecological Training*
N. R. Brockington, B.Sc. (*Left September,* 1953)	*Ecological Training*
I. Langdale Brown, B.Sc. (*Left September,* 1953)	*Ecological Training*
E. C. Trump, B.Sc. (*Left September,* 1953)	*Ecological Training*
W. D. Clayton (*From November,* 1953)	*Ecological Training*
C. F. Hemming (Desert Locust Survey) (*From October,* 1953)	*Ecological Training*

V. F. Eastop, B.Sc. (*Colonial Research Fellow*)	*Entomology*

NOTE

Owing to the alteration of the East Africa High Commission financial year from January 1—December 31 to July 1—June 30, a corresponding change will necessarily be made in the Annual Reports of this Organisation. The present Report for 1953 is the last one that will refer to the calendar year. Will librarians and others concerned with documentation, please note that the next Report will deal with the eighteen months January, 1954—June, 1955, and that thereafter reports will cover the twelve-month period July—June.

REPORT BY THE DIRECTOR

The State of Emergency declared by the Kenya Government in October 1952 lasted throughout 1953. The whole of the male European staff, except for two members who are in the Special Police, has continued its service in the Kenya Police Reserve. These conditions have adversely affected the research output at the Muguga headquarters, because the calls of the Authorities on the services of the Muguga K.P.R. Section have increased. In addition, work at outside centres has been affected, either because of difficulties in making the journey or because time could not be spared. At the end of 1953 there were, unfortunately, no indications of an early return to normal research and administrative conditions.

Construction.—During 1953 the Maintenance Superintendent and his Asian and African staff completed the bulk of the outstanding construction provided for in the present Scheme financed under the Colonial Development and Welfare Acts. As before, all designs and plans have been made by the Maintenance Superintendent, and direct labour has been employed, so that considerable savings in costs as compared with architects' and contractors' charges have been made. This would not have been possible but for the fully equipped workshops that were included as an essential part of the original Scheme in 1947. The joinery, machine, welding and blacksmith shops have been fully employed in this work, and in making and preparing a variety of laboratory apparatus, maintaining vehicles and farm machinery and constructing various spares that were either unobtainable or excessively costly. Figures of costings are kept in sufficient detail so that, when applicable, charges can be debited to the appropriate Divisions and Sections of the Station. These figures also show the savings that can be made in certain cases. Thus, wooden-slat sun blinds for our experimental greenhouses, obtained from home, cost £34 each, exclusive of freight charges. Sun blinds required at a later date for other greenhouses were made in the workshops at a cost, including workshop overheads, of £6 each. The slats were made from old packing cases, and the pulleys were cast from scrap aluminium; the only items that had to be purchased were the blind cords, the paint and a few bolts and nuts.

The works completed during the year for E.A.A.F.R.O. and attached Schemes were as follows:—

(a) *Houses and Buildings.* One European, three Asian, thirteen Senior Grade African quarters; dispensary; African Social Hall with ancillary buildings; two insectaries.

(b) *Joint Animal Industry Division.* Completion of metabolism laboratory and Kjeldahl rooms; dairy and milking parlour, concrete cattle dip, cattle yard, feeding and water troughs; erection of weigh bridge; poultry houses and appliances.

(c) *Plant Quarantine.* Laboratory and office; erection of eight greenhouses with water and electrical services.

(d) *Other Works.* Extensive repairs, including deep underpinning, have unfortunately again been necessary to several

buildings, because of subsidences due to the deeply fissured soil. As a matter of urgency, the construction of the High Commission Pavilion and twenty booths for the Royal Agricultural Show was taken in hand and successfully completed by the opening date.

With the substantial completion of the construction programme, it was possible to give more attention to making the panelling and furniture for the Conference Room and the library furniture, using the special timbers given for that purpose by the Governments of Uganda and Tanganyika.

This is a satisfactory record of work done. Throughout, substantial economies were made possible by using the workshop facilities and by employing direct labour. Indeed, only one contract was placed in 1953; this was for the tarmac surfacing of the roads around the laboratory area, in order to reduce the dust from the murrum roads which was adversely affecting much of the scientific work. The workshop staff has now been reduced to that required for maintenance only.

The completion of the Plant Quarantine Station allows official operations to begin on the 1st January, 1954. It was built with funds provided by the three East African territories, and will be operated on their behalf by E.A.A.F.R.O.

The African Social Hall, designed by the Maintenance Superintendent, and erected under his supervision by direct labour, contains, in addition to a large Hall, a Reading Room, kitchen, buttery and eating room and a small court-yard. The African Staff Welfare Association made an appreciable contribution to the building and furnishing costs, from its own funds. The Hall was opened on the 19th December 1953 by Sir Vincent Glenday, K.C.M.G., Speaker of the Central Legislative Assembly, and an address was given by Mr. B. A. Ohanga, C.L.A.

Publicity

In the conditions of East Africa, special efforts must be devoted to publicising the work of the Research Organisations. The necessity for long-term or basic research, even in subjects of such vital importance to East Africa as agriculture, forestry and animal industry, is by no means generally understood, even by the educated public. Indeed, there is often a desire to apply the apparently simple—but specious—principle that, if public funds are to be spent on research, there should be from each research project an identifiable immediate financial return exceeding the expenditure incurred on it. But, in agricultural research, cause and effect are seldom so simply connected as that. The path between a saving of costs or an increased return, due to an altered or new agricultural practice, and the research that ultimately produced it, is usually so involved that it is impossible to follow it back with any certainty; all that can be said is that, but for various earlier researches, some of them bearing no apparent relation to the new practice, the practical improvement would not have arisen. To take an example from the present Report: the

results of researches into rainfall reliability and into some aspects of soil classification will be of much significance in delimiting marginal areas for certain agricultural systems, and thus will be of considerable financial importance in increasing output, but especially in deciding whether a proposed expenditure is justifiable. But when the researches were inaugurated, no such use of their results could have been foreseen and, had the criterion of probable financial return been in operation, the proposed investigations would have been rejected.

In last year's Report it was stated that of the various forms of publicity lying within our power, the most lasting and effective was the encouragement of visits to Muguga. Over 400 visitors came in 1952, although the Emergency extended over the last three months of that year. As the Emergency continued over the whole of 1953, we were prepared for a marked drop in the number. Hence it is gratifying to record that, far from a decrease, the number rose to well over 550. This increase of one-third in a period where a marked decrease was felt to be inevitable, is a very strong indication that in a normal year we must expect large numbers of visitors. The various classes of visitors, Europeans, Asians and Africans, include organised parties and individuals; technical and scientific enquirers; Government officers on courses; farmers and Young Farmers' Clubs; and members of the general public. The necessity of making available a thoroughly competent and experienced officer to deal with this influx, foreshadowed in last year's Report, has thus become a live issue considerably sooner than was expected, and it is hoped to make satisfactory arrangements early in 1954. The officer must be able to receive all classes of scientific and general visitors and to give them an account, adapted to the particular audience, of all the work in hand, both in its technical aspects and its practical implications. If the work is to be done at all, it must be done well, because, besides provoding visitors of all types with a properly balanced picture of the work in hand, it has the further purpose of confining the, at present, frequent interruptions experienced by research officers to those occasions when a specialist visitor comes to discuss the research in detail

Co-ordination

Only brief references are necessary, because a full review of the machinery devised to secure co-ordination with other research bodies and with territorial Departments was given in last year's Report (pp. 11—15).

The most important development during the year has been the creation of a Governing Body for the Natural Resources group of High Commission Research Services. The Research Organisations concerned, besides E.A.A.F.R.O., are the East African Veterinary Research Organisation, The East African Fishery Research Organisation and the East African Marine Fishery Research Organisation. The Governing Body has advisory duties to the East Africa High Commission in respect of these four Research Organisations, and will hold its first meeting early in 1954.

Technical Co-ordinating Committees met during the year and there were three meetings of Specialist Committees.

The Specialist Committee on Soil Fertility held a successful two-day Conference at Muguga attended also by a number of observers. The whole of the field experiments in East Africa were passed under review in a series of papers and in the discussion thereon. The papers were presented on a territorial basis, and dealt with both farm and plantation crops: cereals, leys, grass, pyrethrum, tobacco, coffee, tea and sisal. The Conference also discussed the scientific interpretation of these crop responses, with special reference to the phosphorus and nitrogen status of the soil, the effects of soil type and plant factors. An account of the discussion and a summary of the papers has appeared in the *East African Agricultural Journal* (1953, **19,** pp. 19—57).

The Specialist Committee on Plant Breeding and Genetics has been enlarged by the inclusion of Plant Pathologists, and the title of the Committee changed to Agricultural Botany. A high proportion of plant-breeding problems is concerned with breeding for immunity or resistance to diseases, and an excellent example of this is provided by the maize rust problem discussed in the present Report; therefore there are obvious advantages in bringing Pathologists and Geneticists together in one Committee. This enlarged Committee met during the year at Muguga, and in addition to its major work—the discussion of the maize rust problem—it examined the progress in cassava-breeding that has been under way for a number of years at Amani, the Panama disease of bananas, and the possibilities of sugar-cane breeding.

The Specialist Committee on Animal Industry met for the first time this year. It necessarily covered a wide field, in preparation for more specific and limited discussions at later meetings. It did, however, stress the importance of investigations aimed at improving and standardising techniques, and it also emphasised the need for a central bureau of Animal Industry, which, besides abstracting and circulating relevant information, should also be a recording office for the collection and collation of data from the territorial experiment stations.

Other meetings at Muguga included the Second Forest Nursery Course lasting ten days, and attended by Forest Officers from the three territories, and a seven-day visit by the Tanganyika Forest Rangers School. It is the view of the Chief Conservators that in present conditions, E.A.A.F.R.O. is fulfilling a valuable function in holding these combined discussion and instruction courses for Forest Officers. It is intended to continue the Courses until the majority of Forest Officers have attended one.

Meetings of Specialist Committees, working to an arranged agenda and producing recommendations and conclusions on scientific and technical matters, would be of little value if there were not at the same time full freedom for direct informal contacts on all scientific and technical matters between officers of this Organisation and their opposite numbers in the other Research Bodies and territorial Departments in East Africa. Every encouragement is given to these contacts because it is mainly through them that the business of the Specialist Committees emerges and is rendered effective.

The central position of E.A.A.F.R.O., with its range of specialised laboratories, enables it to provide various services in addition to those indicated above.

The Forest Pathologist of the Kenya Forest Department has been provided with laboratory accommodation.

Prof. Matthias Stelly, of the Department of Agronomy at the University of Georgia, U.S.A., spent the period from August, 1952, to July, 1953, attached to the Kenya Department of Agriculture, under the provisions of the Mutual Security Agency. Throughout this time he was provided with laboratory and housing accommodation at E.A.A.F.R.O. Prof. Stelly was studying, and making recommendations upon, the maintenance of soil fertility in the Kenya Highlands, with special reference to the effects of crop rotations, organic manures and commercial fertilisers. His association over this period with members of the E.A.A.F.R.O. staff interested in these matters was of considerable mutual value.

Mr. Osborne of the Sisal Research Station, Mlangano, Tanganyika, spent ten weeks in the E.A.A.F.R.O. Spectrographic Section learning the techniques of these methods. Subsequently, the Head of the Section spent some time at Mlangano assembling the apparatus and getting it into working order.

The arrangement with the Overseas Food Corporation, begun in 1951, continued to work successfully throughout 1953. Originally the arrangement was to extend to March 1953, and then to be reviewed. The fact that the O.F.C. found it possible to extend the time to the end of 1953 has enabled the programmes of three O.F.C. officers to be closely integrated with those of the corresponding Sections of E.A.A.F.R.O.

Visits outside East Africa were made for research and advisory purposes to Nyasaland by the members of the Ecology Training Scheme, and the Termite Research Scheme. The Head of the Soil Physics Section visited the Sudan to advise on an extensive programme for studying water balance under irrigation conditions.

A series of memoranda was prepared for the attention of the Royal Commission that is examining land and population problems in East Africa. These papers, which have been discussed in detail with the Commission, cover those lines of work at E.A.A.F.R.O. of special use to the Commission, and particular attention was directed to problems connected with hydrology, because of the vital bearing of water availability, in East African conditions, on all forms of proposed development, industrial and agricultural, urban and rural. In some respects these memoranda are a corollary of the important report on forest management in East Africa in relation to climate, soil and water resources, made by Dr. Hursh, of the United States Forest Service, and printed on pp. 26—35 of the 1952 E.A.A.F.R.O. Report.

Scientific Work of the Organisation

The long-range programme that was drawn up after exhaustive discussion with all the interests concerned has required no major

alteration during 1953. For the same reasons as those given in last year's Report, the present discussion will deal largely with parts of the programme that have come into special prominence, rather than with an over-all review of the past year's work in each Section. The Section Reports on pp. 19 to 76 should be consulted for that information.

The four lines of work selected for special mention deal with (a) a swift and striking action against a rust disease of maize that has already caused grave damage in other parts of Africa; (b) insecticide researches which have put the subject in a new light and, for the first time, provided a method for assessing the practical value of an application, and hence for a measurement of its economic significance; (c) the assessment of the agricultural value of rainfall, using a simple method of specifying its reliability in areas where the fall is erratic and where, therefore, a yearly average is misleading; (d) the work of the Soil Physics Section; (e) the work of the joint Animal Industry Division.

Before dealing with each of these in detail, it is worth pointing out that the second and third aptly illustrate the point already made above in the paragraphs on publicity; the investigations were not initiated in response to requests for a means of measuring the economic value of insecticides, and on how to use rainfall statistics to decide whether a particular agricultural system could safely be practised in a given area; indeed, had such requests been received, and had the investigations been put in hand for the reason that the solutions would have a cash value to impress the critics of research, it is quite likely that nothing much would have come out of the work. The reason is simple: successful answers by scientific institutions to practical questions of this kind almost invariably depend on the pre-existence of scientific facts or experimental techniques that can be exploited to get the answer. Very often, of course, the exploitation itself calls for a high level of scientific ingenuity, but the fact or the technique must first be available. In the two examples mentioned, however, the sequence was the other way around, and it should be noted that this order, in which a piece of research, pursued for its own end, leads to an unexpected practical application, is at least as common as the other. The insecticide developments, for example, were the sequel to an attempt to devise a technique for insecticide trials that would be suitable for a strong-flying and mobile insect; while the rainfall work originated in a study of the statistical patterns of rainfall distributions over the year.

(a) *Rust Disease of maize*

Reference was made in the 1952 Report (pp. 13 and 14) to the danger that threatened East Africa from this fungus, and to the swift action taken by E.A.A.F.R.O., in conjunction with the territories, for research into preventive measures before the disease got out of hand, as it has alsewhere in Africa. The fungus is believed to be indigenous to Central America, and it was therefore possible that resistant maize types would be found there, so seeds of a considerable number of types were obtained as the nucleus for our work. It was necessary to devise a method for testing the resistance of their progeny to the strains of the fungus that exist in East Africa: to begin with, each

test is made with spores originating at the Coast and in Uganda—widely separated regions, with the possibility in mind that different physiological races may have developed. The test developed is a greenhouse one employed on seedling plants. Under this test all East African varieties of maize so far tested have proved to be susceptible, as perhaps would be expected, while among the exotics a small number were shown to have various degrees of resistance. Plant-breeding studies have shown that this seedling or juvenile resistance is transferable to the East African maizes, and that it follows the expected genetical inheritance. The question whether the seedling resistance is maintained throughout the whole growth of the plant has still to be decided, but by analogy with wheat-rust studies, where the connection is an invariable one, there are strong reasons for hoping pending the field trials in the territories, that maize will behave in this connection as wheat does. Thus, in a very short space of time, the work has progressed from the stage of promise to one of a reasonably high degree of probability. Throughout, close co-operation with Department of Agriculture officers has been maintained directly, and also through the medium of the Specialist Committee on Agricultural Botany. E.A.A.F.R.O. is continuing its intensive testing system of glasshouse tests as a guide to its breeding programme; the resistant lines will be passed to the Departments of Agriculture for field-scale breeding and selection, so that the genes for resistance in the E.A.A.F.R.O. lines may be transferred, on an agreed plan, to suitable local maize types. When full allowance is made for the fact that only resistant and not immune types are available, and for the possible circumventing of this resistance by new physiological races of the fungus, the fact remains that by prompt central research and the mobilising of inter-territorial co-operation, the danger of devastating losses in a staple food has been greatly lessened.

(b) *Insecticide researches*

Since its inception, the E.A.A.F.R.O. research officer engaged in this work has been stationed at the Empire Cotton Growing Corporation Cotton Research Station, Namulonge, Uganda. This arrangement has proved highly satisfactory to all concerned, and a full share of the credit for the achievements about to be discussed must be given to the opportunities for co-operative work and discussion at Namulonge. When the work began, insecticide research was considered primarily from the directions of finding more and more potent chemicals, and examining spraying techniques that would permit of less and less quantities being required. It was assumed that once these problems were settled, spraying to deal with an actual insect attack, or preventive spraying, as the case might be, were purely routine measures raising few scientific problems. However, the work to be discussed shows that it is precisely here where the problems of insecticides research really begin. Indeed, for certain crops and insect pests the whole question of how and when to use insecticides requires a new line of approach. There is not necessarily a loss of yield even under prolonged insect attacks of medium intensity. Again, actual reductions of yield can occur, rather than gains, if an early insect attack is promptly dealt with by insecticides. These paradoxes arise because the insecticide and the insect are only two factors in a complex made up of the physiology and growth-habit of the plant, the kind of weather in the growing season, the nature of

the insect, and the insecticide itself. The work has been done mainly on cotton, which is a plant that forms many more fruiting points than can be brought to maturity as ripe cotton bolls. Thus, loss of fruiting points by early insect attack may mean only that the crop will be formed on the later fruiting points. In this kind of attack, early spraying would give an earlier but not a larger crop. There is the corollary that spraying against a later attack would produce an increase in yield. Therefore the habit of the plant to form a bigger vegetative structure if the early-formed fruiting points are destroyed, may enable it to carry on this bigger framework more fruiting points and a larger total crop.

The conclusion is that the question whether it is economic to use insecticides depends on quite a number of factors. Thus, in the conditions in which the experimental work was done, the use of insecticides could have been limited to one month: this is a four-fold reduction on normal practice, and the reduced application would have been economically profitable.

It is quite clear that a new field of work has been opened, and it should now be possible to give precision where, so far, only qualitative conclusions have been avaliable. It is, unfortunately no longer possible for this work to be carried on by an E.A.A.F.R.O. officer at Namulonge because, owing to increase of Cotton Research Station staff, the house and laboratory hitherto used are no longer available. The work will therefore be transferred to a new Colonial Development and Welfare Scheme at Ilonga in Tanganyika, where it can be repeated under the very different conditions of that area, thus widening our knowledge of the relation between the cotton plant, its environment, its pests and their control.

(c) *Specification of reliability of rainfall*

This work has been done jointly by the Plant Physiology and Statistical Sections. It has aroused much interest, and a considerable number of requests has already been received for specific information about rainfall reliability at various places. The purpose and the applications of the work can be easily seen by comparing East African rainfall conditions with those for a different region, e.g., the Eastern part of Great Britain. Thus, at Rothamsted Experimental Station, where long records are available, the average annual rainfall of about 30 inches is distributed evenly over the year. Each month receives more than 2 inches and, with one exception where the figure is just exceeded, less than 3 inches. Clearly, in these conditions, agriculture suffers the minimum vicissitudes from the weather, and special methods, such as dry-farming, or the conservation of fodder for animals, are unnecessary. But conditions over much of East Africa are in marked contrast. Not only are there violent differences from year to year in the total rainfall, but its distribution is equally erratic and, except in the most general way, the farmer cannot count on any particular month behaving in the same way as in previous years. In such conditions, figures for average amounts are of far less value to him than a knowledge of the reliability of the rainfall.

Rainfall figures were therefore examined from the viewpoint of reliability; and the criterion adopted was to assess the percentage

probability that any particular area would receive less than a certain amount of rain in the year. The mathematical examination of the rainfall figures showed that the distribution usually follows the normal curve. This makes it possible to define the distribution by two measurements, the mean, or average, and the standard deviation, which is a measure of the variation around the mean; and then, by standard statistical procedures, to calculate the reliability of rainfall above or below certain levels. Thus, for a place having an average rainfall of 30 inches, with a standard deviation of 5 inches, the following results would be found:—

Rainfall	*Probability*
over 45 inches	very seldom
over 40 inches	2%
below 25 inches	16%
below 20 inches	2%
below 15 inches	very seldom

These figures show that a farmer in that area wishing to practice a system of agriculture that needs about 30 inches of rain per annum could do so with confidence, because he could rely on getting at least 25 inches of rain, in five years out of six over a long period of years and, of these deficient years, in only one year in fifty would the rainfall be below 20 inches.

This kind of information can obviously be mapped in various ways The simplest and most useful method for agricultural purposes is to show the probability that the rainfall will fail to reach a critical minimum value needed by a particular crop or agricultural system. If the year's total is below this critical value in one year out of every three, i.e., approximately 30 per cent. over a long period of years, then that particular system of agriculture has poor chances of economic survival in that area. It is clear that the chosen minimum critical value can be varied in accordance with the conditions under investigation.

Two maps have been prepared showing, for East Africa as a whole, the percentage probability that the annual rainfall will fail to reach 20 inches and 30 inches. These two values were selected because 20 inches annually represents the quantity of rain needed, in East African conditions of subsistence farming, to give a reasonable yield of a fairly drought-resistant crop such as sorghum, while 30 inches applies to a farming system in which maize is included.

This system of expressing rainfall reliability is of greater value than conventional rainfall statistics in a number of directions. It can be used, for example, to select areas for settlement and development where the reliability of the rainfall is reasonably high, even though the actual fall may not be very great. One development of the method, now under examination, is to apply it to seasonal rainfall, e.g., the 'long' rains.

(d) *Soil Physics*

In the 1952 Report (pp. 8, 9) the Soil Physics Section was one of the three new Sections whose programme was briefly mentioned. During the present year the Section has carried out in all three territories a full programme which is described on pp. 53—59. The work is a good example of how the three stages of (i) basic research, (ii) technological investigation and (iii) introduction to practice can sometimes be closely fitted together; it also shows how varied and flexible are the forms of collaboration that need to be devised for the execution of an over-all programme of this kind. Thus, work is being done for (or jointly with) the P.W.D., Agriculture and Forestry Departments, Soil Conservation Service, Coffee Research Station, and the Overseas Food Corporation.

The studies cover a wide range of climate, from the heavy rainfall forest areas to dry-farming conditions. The underground water reserves, that are tapped by boreholes for piped water supplies, are replenished largely by the rain that falls on forest-covered catchment areas. Therefore adequate acreages and appropriate vegetation are both of high importance in these catchment areas, if the maximum re-charge of the underground water table is to be secured. There may be conflicting claims between indigenous vegetation and plantations of trees felled at intervals for commercial timber. In this connection, the query whether it would be safe to replace indigenous bamboo by plantations of cypress, was briefly mentioned last year as an example; it is referred to in more detail in this year's Sectional Report.

A further example of the value of these physical measurements is given by the study of water use by Kikuyu-grass (*Pennisetum clandestinum*) pastures. In the area in which this work was done, it has been shown that this deep-rooting grass intercepts and utilises the whole of the rainfall, except for certain amounts that, penerating rapidly down cracks and old root channels in times of intense rainfall, pass beyond the range of the grass roots. In this area a permanent stream existed until the original bush vegetation was replaced by Kikuyu-grass. Clearly, the replacement of bush by Kikuyu-grass has appreciably changed the water régime.

The erratic and often intense storms over much of East Africa are liable to cause erosion. For this reason the practice of terracing an expensive operation, and the absence of reliable data for guidance may well have led to unnecessary expenditure. A full-scale experiment, combining the effects of terracing, of slope and of various agricultural systems has therefore been laid out with the object of obtaining the primary data needed. Water balance studies will be made by measurements of surface run-off and of water penetrating below the root-range of the crops and leys.

The agricultural system known as dry-farming consists essentially in growing a crop in alternate years, so that the rain of the fallow year, held in the soil, is available together with the rain of the crop year for the water needs of that crop. Over large areas of East Africa the rainfall is low enough to warrant dry-farming, even though

the bare soil surface of the fallow year invites erosion troubles. Experiments on variants of the dry-farming technique have already produced important results. It has been shown that indigenous weeds make great demands on soil water; a weedy-fallow uses as much water as a crop of maize or sorghum, thus defeating the whole object of the fallow. Conversely, a quick-growing, short-lived and shallow-rooting crop uses very little more water than is lost by evaporation from a bare-fallow, and has the further advantage that the dead matt is a safeguard against erosion.

Other researches in the programme of the Section deal with problems of soil structure. Some years ago attention was given in a agricultural systems, and the slopes of the terraces themselves, have had to be based largely on intuition and empiricism. Terracing is land as a means of soil conservation is increasing. Decisions on such matters as the maximum slopes that can be left unterraced in various number of laboratories to the finding that tropical land, rested for a period under certain grasses, regained a crumb structure that characterises good tilth in temperate zone soils. Recent work in the Soil Physics Section on methods used for assessing the development of this soil structure have shown that the measurements are of little practical value for indicating the field behaviour of soils. Therefore considerable doubt now exists about the precise functions of the grass ley: the structure-effect may well be a quite unimportant incidental accompaniment of fertility improvement due to the physical translocation of plant nutrients brought from the lower depths of soil by the deep-ranging roots, and eventually deposited in the top soil when the ley is turned-in.

(e) *Animal Industry*

This joint Division of E.A.A.F.R.O. and E.A.V.R.O. has had a full year. Development of the experimental areas was slowed up because of unfavourable weather, although the low rainfall assisted in clearing couch grass. Clearing the land of ticks has been continued with the immune cattle kindly loaned by the Department of Veterinary Services, Kenya.

Although the experimental work has been handicapped by difficulties in recruitment, a great deal of essential preliminary research has been carried out which is given in detail later (pp. 66 to 76).

Much attention was given in the early discussions with the territories to the correct place to be occupied by the Division and the farm in relation to the territorial activities in the field of animal husbandry. It was agreed that its rightful function was to undertake basic research in problems that were of East African rather than local significance. In pursuance of this conclusion, a long list of such problems was drawn up, and discussed in detail with the Directors of Agriculture, the Directors of Veterinary Services and with their specialist staffs, until the main lines of research and the priorities for specific investigations within each main line were all fully agreed. It will be readily realised that a proportion of these researches must be made in environments different from Muguga, and that for these cases—as indeed, in most of the researches—a prime function of the

Animal Industry Division is to develop suitable experimental techniques that can be used elsewhere, thus ensuring that the methods will be suitably adapted to the problems, and also that results in different centres will be comparable with one another.

It is desirable to stress the importance of studying and developing techniques for animal husbandry experiments and trials in East Africa, if much waste of effort and even erroneous results are to be avoided. In the case of field experiments on crops, the development of statistical methods for designing the experiments and working out the results has enabled crop responses to manures to be accurately measured; in consequence, a number of practical beliefs have had to be corrected. Similarly, studies of animal growth and nutrition, especially the very complex inter-relations between the animal and the pasture, must employ experimental techniques suitable to the problem if the development of animal husbandry is to proceed on sound lines. Full advantage is being taken of advances in this vital but unspectacular work already made in Britain, South Africa, and the United States; but it is of course necessary to test the methods in our own conditions, and to introduce suitable modifications.

Cattle are economically the most important of farm livestock but, until the experimental farm is cleared of East Coast Fever, work with cattle must be deferred, except for the incidental use of the immune animals in the technique studies. This unavoidable delay, coupled with the paucity of available funds and the need to make a start on the immense volume of work which has to be done, led to the decision to push ahead with investigations on sheep, pigs and poultry. Because of their rapid growth and reproductive rates, studies can be carried through a number of succeeding generations at a pace that is impossible with cattle. Although caution is necessary when applying the results from one type of livestock to another, it is unlikely that if, say, a given method of breeding fails in poultry, pigs and sheep, it will succeed with cattle. Again, owing to the large number of genes concerned in the genetic make-up of the productive characters of all classes of livestock, a method of breeding which will preserve an existing gene combination or encourage a more suitable one, not only in poultry but also in pigs and sheep, is worthy of investigation in cattle. In this way, studies can be carried out on the possible effects of environment in causing degeneration in size of exotic stock in spite of the standardised management and feeding in each successive locally-bred generation. Useful information on possibilities of fixing new meat-producing breeds, by interbreeding successive generations of crossbreds, can more quickly be obtained than with more costly and more expensively maintained cattle.

It is often said that fowls differ so essentially from cattle in their digestive processes that nutritional studies on the former can be of little use for the latter. The same could be said of the pig and the sheep; yet much can be learnt if one is studying the efficiency with which comparable foodstuffs are converted into comparable products or the effects of nutritional planes on body composition. The classical example is the Cambridge work on the effects of varying nutritional planes on body conformation. It was first worked out with pigs, but was subsequently found true for sheep, cattle and poultry. Sub-

clinical nutritional deficiencies can probably be investigated more easily in small livestock; whilst studies on possible relationships between such deficiencies and bovine infertility, due to embryonic mortalities, might well be preceded by studies on incubating eggs from suitably conditioned hens.

The small livestock studies are also justified *per se* because, in East Africa, owing to the overwhelming economic importance of cattle, the smaller livestock have received much less research attention. Unsuitable rations can seriously affect not only the quality of pig carcases but also the quantity of food eaten during growth and fattening. The economics of egg and table-bird production can be influenced by the nature of the diet and the percentage hatchability of eggs can be reduced to uneconomic levels by wrong feeding. Certain farmers secure good results; but many, who are satisfied with their present sub-optimal rates of pig growth, egg yields or incubation results, could secure appreciably better returns by adopting sounder management and feeding practices. In the U.S.A., poultry meat is cheap and widely consumed; in the U.K. it is almost a luxury article of diet and apparently unable to compete in price with the more commonly eaten beef. What then is the position in East Africa and what are the prospects of producing table birds at competitive export prices?

It is within this framework that the work of the Division is carried out. The present programme falls into two broad divisions, and many of the experiments are, designedly, short-term ones which, while fitting into the general plan, may also provide early information of practical value for farmers and departmental officers:—

(a) study of the efficiency with which animals utilise various foodstuffs;

(b) the evolution of techniques that will give reliable answers in the widely varying environmental conditions of East Africa.

As already mentioned, the investigations on technique necessarily cover a wide and practically unknown field. They include studies on the best size, shape and number of plots needed to give reliable estimates of herbage yield and composition; the methods of measuring that yield and composition; the corresponding requirements for number of animals in grazing trials, where live weight changes are used as a measure of herbage productivity; the correlation of direct grazing measurements with stall-feeding of the cut herbage. There is also a range of experiments on the rate of food conversion by animals, in which the more rapid growth-rates of small livestock—poultry, sheep and pigs—are used to give quicker answers to various practical points of management. On the nutritional side these exploratory experiments should enable assessments to be made of the minimum nutrient needs for different types of animals at different stages of development, thus giving a better insight into the physiological mechanisms for dealing with various heat loads and for utilising digested nutrients. This, in turn, raises experimental problems of the effect on the digestibility of crude fibre, and of various supplements to the ration. One associated problem, of special import-

ance in East Africa where the rapid growth of herbage leads to big differences in its size, composition and degree of maturity over the season, is the development of some quick and cheap method in place of the classical digestibility trial, for use in preliminary experiments.

Finally, there are two satisfactory matters to report in connection with the whole field of animal industry investigations in East Africa. These are both connected with the experiments under the direct control of the Agricultural and Veterinary Departments in the territories. The first is that the Head of the Animal Industry Division has been asked to go into the experiments in detail, to suggest modifications that may improve them and facilitate co-ordination with others. The second is that Veterinary Departments are now asking for the advice of the E.A.A.F.R.O. Statistical Section in the design of projected animal industry investigations. As the Statistical Section is already working in the closest collaboration with the Animal Industry Division in its own programme, this further co-ordination should be very effective.

It is clear, therefore, that the whole field of animal industry investigations in East Africa, ranging from basic investigations to simple practical trials, is being integrated throughout in a satisfactory way. Paradoxically, the biggest difficulty is the reduction of time available for basic research at Muguga, owing to the extensive tours undertaken at the territorial invitation. This difficulty, however, will decrease to manageable proportions once the initial tours have been completed, and the recruitment of research officers up to establishment has been made.

Staff

There have been few changes during the year. Dr. Jane Meiklejohn completed in August her period of secondment from the Rothamsted Experimental Sstation as microbiologist. It was the intention that Dr. Rudd Jones should take charge of this work on return from his Post-doctorate Fellowship of the Canadian National Research Council. Unfortunately, he resigned, and this important line of work has had to be indefinitely postponed. Resignations were also received from Miss Maclean (Scientific Assistant), Mrs. Skipper and Mrs. Scott (Clerical Assistants).

Messrs. Langdale Brown, Trump and Brockington of the Ecology Training Scheme completed their training in September. Messrs. Clayton and Hemming (the latter from the Desert Locust Survey) joined towards the end of the year. In the Termite Research Scheme Mr. Sands was in charge of the work centred in East Africa, and was also engaged in the training of Messrs. Wilkinson and Williams, who arrived in June and September respectively.

Difficulties in interpretation of the terms of the Colonial Research Service and the Colonial Superannuation Scheme, to which reference was made both in the 1952 and 1951 Reports, have persisted throughout 1953.

Mr. Hesse was awarded the Ph.D. of London University.

SECTIONAL REPORTS

Plant Pathology

Staff

H. H. Storey ..... *Deputy Director*
F. M. L. Sheffield ..... *Plant Pathologist*
A. K. Ryland ..... *Scientific Assistant*
V. F. Eastop ..... *Colonial Research Fellow*

There have been several changes in the research of the Section. The resignation of Dr. Rudd Jones left us without a pathologist for forestry problems; but his work is being continued by Mr. I. A. S. Gibson, Pathologist to the Kenya Forestry Department, to whom laboratory and glasshouse space have been allocated at Muguga.

Dr. Sheffield continued work on virus diseases of Sweet potatoes after her return from overseas leave. Investigations on rosette disease of groundnuts have been discontinued at Muguga; although Dr. Evans, working for the Overseas Food Corporation, under the arrangement for general scientific supervision by E.A.A.F.R.O., has continued his studies of rosette and its aphid vector and has obtained important results. His report appears in the O.F.C. Section (pp. 80—88).

The rust disease of maize, *Puccinia polysora* Underw., has occupied most of the time of staff at Muguga. Mr. Eastop, a Colonial Research Fellow, has continued his studies of the taxonomy and biology of aphids.

Rust Disease of Maize caused by Puccinia Polysora Underw.

H. H. Storey and A. K. Ryland

The circumstances leading to the inclusion of this problem in E.A.A.F.R.O. programme were set out in the 1952 Report. A year's experience has confirmed the soundness of our decision to give it high priority. Since the first finding of *Puccinia polysora* in mid-1952 in Kenya and Tanganyika, the fungus appeared in Uganda and Zanzibar also; and reports have reached us of its presence in Northern and Southern Rhodesia, Nyasaland, Portuguese East Africa, Madagascar, Mauritius, Reunion and Somalia. Authorities to the south have expressed great concern over the danger to their maize crops, even though we are still without conclusive estimates of the amount of damage that the disease can cause in eastern Africa.

The guiding principle of the E.A.A.F.R.O. work was enunciated as long ago as November, 1951, by the Specialist Committee on Plant Breeding: that, since *Puccinia polysora* is believed to be indigenous to Central America, it is likely that maize types have evolved there that are resistant to it; and, therefore, that the search for resistant maize for East Africa should concentrate on Central American material. The possibility, however, was foreseen that new rust strains might become established in East Africa and that American maizes might prove to be susceptible to them.

A policy of introducing Central American maizes, in advance of the appearance of *P. polysora* here, was considered and rejected for various reasons. When the fungus had appeared in East Africa in mid-1952, the way was clear for local research. E.A.A.F.R.O. undertook to collect exotic maize types and to carry out intensive testing for juvenile resistance in the glasshouses at Muguga; field tests in 1953 were to be undertaken at Kawanda (Department of Agriculture, Uganda), Kibarani, Kenya Coast (Department of Agriculture, Kenya) and Kizugu, near Amani (E.A.A.F.R.O.).

E.A.A.F.R.O. started experimental work at Muguga in November 1952. In this we had the model of the highly developed work on wheat rusts and particularly local work under Dr. R. M. Nattrass, from whom we received much help in the early stages. A standard technique for resistance tests had been established by March 1953, when a start was made in testing exotic maizes of Central American origin. The first of the F1 seed from the early selections became available for test in September 1953; these tests are continuing, but many results had been obtained up to the end of the year.

During this period 177 maize types have been received from outside East Africa; of these 152 are from America. All of these have been tested in our glasshouses. In addition we have received a collection of some 750 varieties and lines of maize from the Union of South Africa; of these a small selection only were under test at the end of the year. A further consignment is believed to be in transit from Costa Rica. We are indebted to many correspondents in Africa, Central America and the West Indies for their co-operation.

Our method for testing maize seedlings for resistance to *P. polysora* will be described in detail elsewhere. Briefly it consists in inoculating two leaves of each seedling with fresh uredospores and providing the necessary humid conditions for infection to occur. On a susceptible seedling this infection results in the appearance of uredosori, normally fully developed after fourteen days.

In each experiment we have inoculated half of the maize seedlings with spores from an original collection from the Coast and half with spores from Uganda. This precaution was taken in case different physiological races of the fungus had become established in these widely separated regions. Seedlings selected on their behaviour in the tests have been transplanted to buckets and grown to maturity in a large glasshouse. Here the ordinary methods for controlling pollination have been used to obtain selfed and crossed seed.

As our work developed it became evident that two markedly different classes of reaction could occur in the inoculated leaves. With many maize lines the differentiation into these two classes was clear-cut; but with some the picture was somewhat confused with intermediate forms. In the first class the leaf developed large, spreading, often confluent sori, which produced great numbers of spores, without severe chlorosis or necrosis of the leaf; in the second, small necrotic areas appeared on the leaf, and either no sori at all developed or minute sori producing only a small quantity of spores. The first reaction indicates high susceptibility at the seedling stage, and, since

it is shown by varieties known to be susceptible in the field, the test appears fairly to place these plants in the susceptible class. What it fails to do is to show any possible *degrees* of susceptibility; it tells us nothing of the extent to which the affected plant will be damaged by the disease in the field. It is thus possible that among varieties classed by us as susceptible there may be some that are capable of giving a satisfactory yield under conditions of severe rust infection.

We have, however, concentrated our attention on the reaction of the second type, which indicates a definite form of tissue resistance to the propagation of the fungus. The modern view is that the necrotic areas, such as we obtain, result from the killing of the plant tissues that are invaded by the fungus mycelium; and that this mycelium becomes starved in consequence and is able to produce few or no spores. The reaction of the plant is therefore one of hypersensitivity to the fungus rather than of resistance to its invasion. Plants showing this reaction might be damaged, through the loss of functional leaf area, if they were subjected to heavy and repeated natural inoculation with spores; their full economic value is to be obtained when large areas are planted with them, so that the spore density in the areas is reduced to a low level.

The following results have been obtained during the year. Of 42 maize varieties and lines from sources in eastern Africa, none has shown the hypersensitive reaction. Of 25 received from Mexico (through the West African Rust Research Unit) and from Colombia, all but ten were susceptible; but among these ten were plants showing the hypersensitive reaction. Families raised from these resistant individuals by selfing and by crossing have shown similar resistance in all or some of their members.

In certain others of our imported maizes we have found suggestions of resistance similar to the above or sometimes differing from it. These are under study and we are not yet able to interpret our observations. In all more than seven hundred resistance tests have been completed during the year.

Our work has therefore shown that inherited factors conferring a form of juvenile resistance to *P. polysora* may exist in maizes imported from Central America; and that this resistance can be transferred to local African maizes, which are themselves (so far as experience shows to date) all susceptible. It is necessary, however, to emphasize that the E.A.A.F.R.O. work has been concerned only with *juvenile* resistance. We have as yet little evidence to show that resistance in a seedling implies maintained resistance throughout growth. Wheat-rust studies, however, have shown that seedling resistance invariably implies mature-plant resistance; while seedling susceptibility may give way to resistance as the plant matures. It is reasonable to hope that maize may behave similarly; but only field tests can give a final answer.

Field tests have, in fact, been in progress, simultaneously with the Muguga glasshouse work, by E.A.A.F.R.O. officers (Mr. Gourlay and Mr. Jennings) at Kizugu, near Amani, Tanganyika, and by the Kenya and Uganda Departments at Kibarani and Kawanda respec-

tively. The Amani experiments largely failed through lack of rains at the essential stage in the growth of the maize; but so far as recording of behaviour to rust was possible the results seemed to conform reasonably with the glasshouse classifications. These field tests, however, were carried out before the Muguga work had made clear what kind of reaction was to be looked for in the field and they cannot be regarded as satisfactory confirmation of our juvenile tests. This first year's work showed that Kizugu was likely to be a useful testing ground, since susceptible varieties planted at the best season were very severely affected by the rust.

The results of the Uganda and Kenya trials will be reported on by the Departments concerned.

The closest co-operation has been maintained with officers of the Departments of Agriculture. At a meeting of the Specialist Committee on Agricultural Botany held in November 1953, plans for continuing this work co-operatively were fully discussed. In brief, it was agreed that E.A.A.F.R.O. should continue glasshouse tests and breeding on the present intensive system, with a view to producing pure resistant lines and to elucidating the genetics of resistance. Plant breeders in the Departments would undertake field-scale breeding and selection, on an agreed plan to transfer genes for resistance from the E.A.A.F.R.O. lines to locally-adapted maize types.

Diseases of Sweet Potato

F. M. L. Sheffield

Virus Diseases

Previous reports referred to the many symptoms suggestive of virus infection seen on Sweet potato. Most of these were shown to be due to viruses; and it was also found that the virus or virus complex, present in any one plant might produce a wide range of symptoms when transmitted to a range of Sweet potato varieties. The diseases found in the field affected many different varieties; and in order to differentiate between the causal viruses it was necessary to compare their effects on several standard varieties. In 1925 the only stocks available for use as such standards were ones selected as apparently healthy from the field; and some of these were later found to contain latent viruses, which rendered the results of tests unreliable. During 1952 seedlings were grown, and four selected ones were multiplied vegetatively to provide virus-free clones for use as test plants.

Transmissions by grafting to these showed that the viruses existing in the field were not all identical; but on any one variety those tested differed from each other only in the intensity of symptom expression. About a dozen diseased plants obtained from the Research Station at Kawanda, near Kampala, contained viruses which fell into three groups causing very severe, moderately severe and mild diseases. When grafts were made from diseased plants found in the Aberdare Mountains, near Fort Hall, and from others found near Muguga, the symptoms produced were identical with those given by

the very severe form from Kawanda. The most crippling form was obtained from the Jacaranda Experiment Station, near Ruiru, which also provided the mildest form yet seen. The latter was latent in an apparently healthy vine which, after being vegetatively propagated for eighteen months, still shows no symptoms. A virus intermediate in its effects between this and the mildest form from Kawanda was latent in an apparently healthy vine from the Moshi district. In this area well-grown plants with curled and distorted leaves were often found. I was unable to transmit this symptom even to plants thought to be of the same variety, and it is now considered to be a genetical variation similar to that which appeared in some of the seedlings raised for experimental work.

It is not yet possible to say whether the six virus forms which have been separated are different viruses, or whether all or some are related strains, and whether each is a single virus or a complex. Such relationships are usually determined by serological methods or by cross-inoculation. Further attempts to transmit a virus mechanically have failed and, in the absence of this technique, antigens could not be tested for their virus content and serological methods would be unreliable. Some preliminary cross-protection tests, using grafting methods of transmission, gave anomalous results. Little further can be done to identify the viruses or determine their inter-relationships until an alternative method of transmission is found.

This is also necessary before any real attempt can be made to find out whether alternative host plants exist. Attempts were made to infect other species of *Ipomoea* by approach-grafting methods, but, although unions formed, they were apparently not true ones. If one plant was severed from its roots, it died; and, if both remained on their roots, the disease was not transmitted.

An intensive search for an insect vector or vectors is now starting. Experiments with three aphid species have met with no success. Although a number of insect species may be found on Sweet potato, usually each is present in only small numbers. About a dozen species of sucking insects have been found in a plantation where the disease is spreading, and experiments have been started with these.

Insect Diseases

Erinose of Sweet potato is widespread in parts of Africa and is often a serious disease. It causes excessive hairiness, often completely covering the stem and leaves, stunting, thickening of the stems, abortion of axilliary buds and loss of yield. It is highly contagious and has been shown to be directly due to attack by the Eriophyid mite, identified by Dr. G. O. Evans of the British Museum (Natural History) as being of the genus *Aceria* (Keifer).

In an earlier report mention was made of the very great damage caused by thrips on the coastal plain near Tanga and Mombasa. This insect has now been identified by Dr. Hartwig of South Africa as *Dendrothripoides Ipomeae* (Bgn.).

Aphid Taxonomy and Biology

V. F. Eastop

The first ten months of the year were spent mostly at Muguga, with only short collecting trips to the Overseas Food Corporation stations at Urambo and Nachingwea, in Tanganyika. In November, I moved my headquarters to Nachingwea and remained there for the rest of the year.

Aphid collecting has continued, and sixty-seven species are now known from East Africa. Most of these have previously been described from Africa, Europe or Asia and only about six appear to be new to science, although many of the others have not been recorded from East Africa.

Continuous trapping at Muguga has shown a well-marked period of aphid flight after each rains, due, it is thought, to conditions being favourable at that time for the building up of large populations of winged aphids and perhaps also to favourable flying conditions.

Host-plant transference experiments have been continued; and cultures of the species collected in the field have been kept in the laboratory and insectary in order to rear the different biological forms. Most species collected from plants are now known from both winged and wingless adult viviparae, and the sexual forms of a few species have also been reared.

Internal parasites have been obtained from several aphids. Experiments so far conducted suggest that these parasites are highly specific as to their aphid host. The common species of ladybirds have shown no specificity for aphids.

Trapped insects of several groups other than aphids have been sent to specialists who were known to require this material for study.

Plant Breeding and Genetics

Staff

L. R. Doughty ..... *Plant Breeder-in-Charge* (Eldoret)
D. L. Jennings ..... *Plant Breeder* (Amani)
D. W. Gourlay ..... *Field Experimentalist* (Amani)
T. Graham ..... *Field Assistant* (Eldoret)

Work on plant breeding and genetics has been continued on the two E.A.A.F.R.O. sub-stations at Amani, Tanganyika and Eldoret, Kenya. Field trials in connection with cassava breeding were made as heretofore at Kizugu, near Amani, and the Sisal Experiment Station, Ngomeni, and in addition, in co-operation with the Kenya Department of Agriculture, at Gomatu Estate, Mombasa, by kind permission of Mr. C. D. Gee.

Maize variety trials were run in co-operation with the Kenya Department of Agriculture at Bukura Training Centre in North Nyanza.

The growing seasons at the various sub-stations and experimental areas have on the whole been good; lengthy periods without rain have caused a certain amount of anxiety from time to time but serious trouble did not develop.

Cassava

L. R. Doughty, D. W. Goulay, D. L. Jennings

Breeding

The aim of previous breeding work has been to restore fully tuberous roots to the disease-resistant interspecific hybrids by continued back-crossing to cassava. This has been achieved to a large extent, particularly with the ceara-cassava hybrids, but the level of resistance maintained has not been high enough to meet the requirements of the coastal regions, where mosaic disease is very severe. It is possible that factors for disease resistance have been dispersed during the process of back-crossing, and present work is aimed at reconcentrating them by intercrossing and by inbreeding. It is also proposed to back-cross certain resistant hybrids to their resistant parent in an attempt to elucidate the genetics of resistance. Crossing between the several lines of ceara hybrids, and also crosses of *Dichotoma*, tree cassava and *Melanobasis* hybrids with ceara hybrids were carried out during the first two months of the year. The plants in the old maintenance plots flowered sparsely and it was only possible to pollinate 1,856 flowers. Seed production was also lower than usual, only 696 seeds being harvested. The seedlings are being propagated at Amani and will commence their field trials during the coming year.

Field trials

The replicated resistance trials of 262 clones planted at the Sisal Research Station, Ngomeni, in October and November 1952, were harvested during August. The majority of the clones being tested were from second, third and fourth back-crosses of hybrids of ceara and *Dichotoma* origin to cassava, from the 1947, 1949 and 1950 series of crosses. In addition some first back-crosses of *Melanobasis* hybrids to cassava were tested. The more resistant of these have been selected for inclusion in another resistance trial.

Of the 2,179 clones planted in preliminary elimination trials at Ngomeni and at the Kizugu sub-station in 1952, 496 were selected and planted in replicated resistance trials at Ngomeni during the latter half of October. The remainder were discarded as showing symptoms of mosaic. A further trial, in which 35 selected resistant clones are being re-tested, has also been planted at Kizugu.

Since observations in the greenhouse had indicated that cassava plants may be infected with mosaic virus without showing symptoms,

it was considered that the severity of the resistance trials would be increased if planting material for them was taken from selected plants of the previous year's elimination trials, instead of from clean Amani stocks. This method was therefore used for planting all the resistance trials at Ngomeni, and, at a recording made one month after planting, before the insect vector population was very dense, 14 per cent of the clones under test showed some plants with symptoms of mosaic. Thus, although the plants showed no symptoms of mosaic when the elimination trials were harvested, they had almost certainly been infected with the virus.

The incidence of mosaic in all the trials during the year was above average; but whether this was due to favourable climatic conditions or to changes in the plant spacing is uncertain. There are some indications that a closer spacing, which places the trial plants in closer proximity to the diseased hedgerows, is more effective in causing mosaic symptoms to appear.

Although the majority of the clones selected for retrial at Kizugu and near Mombasa, were highly resistant in previous trials, none of them has remained completely free from mosaic in the present trials and in some cases a high proportion of the plants has succumbed. In the trials near Mombasa the incidence of mosaic was so high that it was decided to curtail their duration and to harvest at 12 months instead of 18 months as originally planned. The reasons for the severity of the disease in this region are not fully understood, but the factors which might possibly have a bearing are:—

(1) Presence of abundant diseased material, as a reservoir for infection.

(2) The close spacing (3′ x 3′) which may produce a more favourable eco-climate for the multiplication of the vector population.

(3) An external environment which may favour the activity of the virus or weaken the resistance reaction of the plant.

(4) The occurrence of a more virulent strain or strains of the virus.

Greenhouse experiments

As was mentioned in the previous report, greenhouse experiments are being carried out in which cassava cuttings are exposed to heavy infestation by the virus vector in the presence of infected material. In early trials it was found that the number of plants which became diseased was lower than expected. The plants however grew strongly in the greenhouse and some of the shoots had to be cut back. It was then observed that there was a tendency for mosaic symptoms to appear on the new shoots produced. In order to investigate this further, an experiment was carried out in which cuttings of a known susceptible variety and a resistant variety were subjected to treatments designed to interfere with normal growth. The two treatments used were (1) cutting back to leave three buds and (2) defoliating and removing the terminal bud. The results were compared with

those from plants allowed to grow naturally. Varying periods of exposure to infection were included.

It is evident that plants can carry the mosaic virus without producing symptoms of mosaic; a set-back to steady growth may lead to the production of visible symptoms. This experiment was carried out in the cold weather when conditions in the greenhouse were possibly unfavourable and the vector population smaller than desirable. A further experiment is now in hand.

Distributions

It is not proposed to distribute any of the varieties selected from this year's resistance trials until they have been given a further trial. A few further distributions of earlier selections have been made to coastal regions. Reports on the yield of these clones from small-scale trials by the Departments of Agriculture continue to be encouraging.

Maintenance of material

During the year, for reasons of economy and efficiency, all the clones which are to be retained have been moved from the maintenance areas at Kwamkoro and successfully established in the Amani nurseries, which have been vacated by the Forestry Department.

A collection of all the varieties and hybrids that are ready for distribution has been established at Eldoret, as an intermediate quarantine against the Brown streak virus. This disease is widespread in the coastal belt but is not prevalent in the up-country cassava growing areas in Kenya, Tanganyika and Uganda. As the disease is often very difficult to diagnose in the stem and leaves, every possible precaution has to be taken in transmitting cuttings to the areas from which the disease is absent. In the comparatively cold climate of Eldoret, any plant carrying this disease should die out. As was to be expected, the rate of growth of cassava in general is slow; but it appears that material will be available for distribution from this centre shortly.

Maize

L. R. Doughty

In a highly organised agricultural industry considerable increases in yield and uniformity are claimed for synthetic hybrids. The production of these hybrids depends on this high degree of organisation, since new seed has to be produced for planting each crop. Under comparatively primitive conditions it is claimed that considerable improvement in maize production can be attained and maintained by simpler methods. Two of these of particular interest have been outlined by Harland and Brieger as applied to indigenous maize in South America. To what extent these methods can be usefully utilised in improving the maize population of East Africa, essentially exotic, although with a fairly long history of cultivation, has still to be determined. The purpose of our work is to study this possibility.

using primarily the maize of the important producing area of Nyanza, Kenya, as our material.

To this end, a collection of maize samples has been made from the various locations of the Nyanza Province. This collection was made possible by the co-operation of officers of the Kenya Department of Agriculture, who obtained cob samples from good farmers in their districts and also bulk samples of maize marketed at certain selected centres in North and South Nyanza. Few samples were available from Central Nyanza as the previous season had been a poor one.

Most of this material was incorporated in trials at Bukura, in North Nyanza, and at Eldoret. The predominant type is a flat white dent. The grain weights of the original samples show a continuous range of variation with a distribution approximating to a normal curve. Also, the yields obtained in the first trials show a similar distribution, and it is possible that the genetic variability is similarly restricted, which may limit the scope for improvement in the local material.

At Eldoret inbred families of similar local material, used in previous years in fertiliser experiments, have been subjected to further selection and inbreeding. The various lines from this material will be compared in field tests in North Nyanza and a start made with recombinations of the more desirable types.

A second line of investigation is a study of the variable material from the Lake Province, Tanganyika, known locally as Katumbili. This is a very different type from the common Nyanza type, containing flints and dents, having in general a much smaller grain and being early maturing. A yellow maize, originating on the coast of Tanganyika, is also being studied.

Streak disease

During the past season some 1,086 maize seedlings were tested for resistance to streak disease and resistant plants selfed or intercrossed. Most of the material tested was from hybrid seed raised in 1940 and 1941. Germination was poor, which was to be expected, but several of the more interesting lines have been maintained. Some selections of Katumbili from the Lake Province of Tanganyika were also tested and all these proved to be susceptible. It is in this region that, in some seasons, this disease is most widespread, and resistant stocks would be very useful. The work was hampered in the early stages by the difficulty experienced in maintaining adequate stocks of infective vectors. When this had been overcome, the onset of dry weather slowed down the development of the transplanted resistant material; hand watering in the open was not very satisfactory and limited greenhouse capacity caused a postponement of further tests until the next growing season. A shaded propogation site is now being prepared which, it is hoped, will prolong the growing season for the resistant maizes.

Resistance to Puccinia polysora

A trial to test a number of varieties of maize for field resistance to *Puccinia polysora* was conducted at Kizugu. Eight East African

and thirty-four exotic varieties were planted between rows of susceptible local material. Since little was known about the incidence of the rust, planting of the trial varieties was delayed until early May, when the rust had appeared on native maize in the locality. Unfortunately this proved to be too late, and, although conditions were favourable throughout the month of May, exceptionally dry weather followed, from which the crop never recovered.

Puccinia polysora made its first appearance about mid-May and had built itself up to severe proportions by mid-June. Attempts to record the severity of the rust on the trial plants were made and results were obtained which broadly confirm the results obtained in the greenhouse tests for juvenile resistance made by the Pathology Section.

Growth was so poor that no attempt was made to cross or sib the resistant plants. A small amount of open-pollinated seed was harvested.

Groundnuts

D. L. Jennings

Interspecific hybridisation

Work has continued on the lines set out in the previous report. The diploid species, *Arachis diogoi*, *A. prostrata* and *A. glabrata* flowered well during the early part of the year and over 1,400 crosses, using pollen from the diploid species on emasculated flowers of the groundnut, have now been made. Two hundred and four of the pollinated flowers have shown a response, which has varied from the production of pegs that failed to produce a fruit to the formation of seedless fruit. The few seeds which have been produced have proved to be almost certainly selfed progeny of the maternal parent.

In view of the failure to cross the species directly, priority has now been given to work with colchicine, in an attempt to double the chromosome number of the diploid species, which may facilitate their crossing with the tetraploid groundnut. In the case of *A. prostrata* an application of 2 per cent. colchicine in agar to the growing point of the plants has given some promising results. Plants with larger stomata, broader leaves and thicker stems have been obtained, and these characters have been maintained through several vegetative generations. The plants are awaiting cytological study; but crosses between them and the groundnut will be attempted when they come into flower. Colchicine work with *A. glabrata* has proved exceedingly difficult; the species is so vigorous underground that any check to the growth of a shoot, such as the application of colchicine entails, causes the shoot to stop growing completely, while all further energy is directed into new growth from below ground. Work on *A. diogoi* has been handicapped by a shortage of seed. Preliminary work suggests that treatment of the seed may be the most useful method to adopt for this species.

Intraspecific crosses of Arachis hypogaea

Although first priority has been given to interspecific work, some further intervarietal crosses have been made, with the object of

combining the desirable habit of the variety Natal Common with seed dormancy and other characters associated with the Mwitunde varieties. Crosses have been made between the varieties Mwitunde, Matavere, Nambiquarae and Natal Common. The F1 seed of these crosses, between a dormant and a non-dormant seeded variety, was dormant.

Preliminary observations on dormant groundnut seed have shown that the testa is an important factor determining the retention of dormancy. Removal of the testa leads to rapid loss of dormancy. Similarly, seed that is harvested before the testa is fully matured tends to lose its its dormancy more quickly.

Striga Hermonthica on Sorghum

L. R. Doughty

Owing to the calls of the streak-resistance tests on greenhouse space at Eldoret very little experimental work on resistance to Striga has been possible. In the tests that have been made the germination of *Striga hermonthica* seed has been very limited even on known susceptible varieties. This may however be attributable to temperature variations. Day temperatures are fairly high; but the fall during the night is considerable and for about half the 24 hours the greenhouse temperatures fall below 60°F. Sorghum grows very satisfactorily in the greenhouse but in the open is decimated by the shoot borer, *Antherigona* sp.

Crop Insecticides

Staff

K. S. McKinlay ..... *Entomologist*

Cotton Pests

Preliminary work at the Cotton Research Station, Namulonge, described in the Annual Reports for 1951 and 1952, showed that the relationship between insect damage and crop loss on cotton in Uganda was so complex that in the first instance insecticides would have to be used as tools to study this relationship. After initial difficulties, caused by the mobility of one of the pests, *Lygus vosseleri* Popp., a suitable technique for field experiments was devised (McKinlay, K.S. 1953 Nature, **171**, 658). The 1953 cotton season has been devoted to a large-scale field experiment at Namulonge using this method. The Government Entomologist has carried out an almost identical trial at the Uganda Agriculture Department's experiment station in the Eastern Province, so that effects of insects on cotton in the two areas can be compared.

As the cotton crop on Namulonge is not yet harvested and I am being transferred to work with the C.D. & W. Insecticide Scheme at Ilonga Research Station, Tanganyika, early in 1954, it is not possible to give a detailed account of the results at the present time. However,

a paper is being prepared in collaboration with Mr. Geering of the Cotton Research Station, and it is hoped that this will be ready for publication within a few months.

The principal points emerging from this work are as follows: Under local conditions, i.e., a long growing season for cotton and a prolonged insect attack of only medium intensity, loss of fruiting points due to insect damage does not inevitably result in a loss of yield. Owing to its structure the cotton plant forms many more potential fruiting points than it can bring to fruition as ripe cotton bolls. Losses of fruiting points due to insect attack in the early part of the season can be compensated for by crop being formed near the top of the plant from later-formed fruiting points. Early spraying gives an earlier but not a larger crop. However, as the season progresses, insect damage is more and more likely to be reflected in loss of yield, for the length of time left during which the plants can compensate for losses is being progressively reduced. Thus late-season spraying does result in an actual increase in yield. Contrary to normal expectation complete protection against insect damage throughout the season appears to give little or no increase in yield over untreated control plants. The mechanism of this effect is still obscure; but it would appear that in the absence of insect attack the plant ripens the earliest formed fruiting points, and gives an early crop on a small structure that limits its ultimate yield. By contrast the untreated plants, which are continuously losing a proportion of their fruiting points, can devote more of their effort to vegetative growth; given a sufficient length of season, they are still producing crop, whereas the completely protected plants have ceased doing so. The ultimate result is that untreated plants show little or no decrease in total yield when compared with the early-cropping of completely protected plants.

Obviously all these effects are dependant upon a long growing season and an attack of only medium intensity. Any increase in the severity of the attack, or any reduction in the length of the growing season, would reduce the powers of compensation of the plant and the optimum period for protection by insecticides.

An early problem that may be solved as a result of this work is the difficulty of reconciling economic use of insecticides with an insect attack of long duration, i.e., approximately four months. It would appear from this year's work that loss of fruiting points due to insects is only critical for a short period under local conditions and that losses outside this period are unimportant, since they are not reflected in yield. In this particular season protection by insecticides could have been limited to one month only. This four-fold reduction in the period over which spraying is needed is possibly sufficient to render the use of insecticides economically profitable. However, the results to date are derived from experimental work on research stations. It is essential that some attempt should be made to assess them under the different conditions in the peasant-grown cotton crop, before large-scale use of insecticides can be safely recommended as economically profitable.

Future Programme

It is hoped to continue this work on the relationship between insect damage and loss of crop under the entirely different conditions found in the cotton-growing areas of the Eastern Province of Tanganyika. Comparison of these results with those already obtained in Uganda should lead to a more general picture of the way in which the cotton plant forms its crop and the way in which this is affected by insect pests. This fundamental information is essential for the proper use of insecticides to control cotton pests.

Plant Physiology

Staff

J. Glover ..... *Plant Physiologist*

C. M. D. Harrison ..... *Temporary Assistant*

Work on Pyrethrum comes to an end this year, except that nutrition studies of Pyrethrum will be merged in the general programme of plant nutrition and will be maintained for a further year. In its place will be substituted a study of various rapid methods of testing soil fertility. Studies of the nutrition of grasses and reliability of rainfall were continued during the year.

Pyrethrum "Bud-Disease"

Spraying trials

Two spraying experiments were conducted during the year. One was at Muguga, the other at Molo. Both showed that massive doses of Bordeaux mixture, applied at 10-day intervals, reduced the percentage of buds which were infected and had no marked detrimental effect on bud production. These confirm the results reported last year.

The Muguga experiment was re-arranged so that residual effects of Bordeaux from last year's spraying could be detected if they existed. No such carry-over was observed. At the end of last year flower and diseased-bud counts were maintained for some weeks after spraying was stopped. Six weeks after spraying ceased the disease rate in the sprayed plots rose to the level of that in the controls and remained at the control level until flowering and bud production ceased.

Bud-disease

In last year's report it was mentioned that the apparent length of time between start of infection and the appearance of microscopic symptoms of disease would have to be re-examined. The result of the diseased-bud count at the end of the spraying trial, reported

above, suggested that the true interval was likely to be six weeks or less.

In the spraying trial the individual yields of flowers and diseased buds had been recorded throughout the season. It was therefore possible to pick from the controls 35 plants which had started to flower in the same week and whose yields throughout had been remarkably close to one another. Thus, uniform material of known behaviour was available for further investigation. A flare-up in disease-rate, lasting for five weeks in mid-season, had occurred in the control plots. The cause of this was sought in earlier climatic records. It was found that five weeks earlier there had been a marked increase in the number of degree-hours spent by the plants below 50°F. Further, throughout the whole season the disease-rate could be related to the number of degree-hours at or below 50°F., 5 weeks earlier. As 50°F. is approximately the mean dew-point at Muguga, the range of mean monthly values over a two-year period being from 47 to 53°F., at 2.30 p.m. and slightly higher at 8.30 a.m., there seems little doubt that the persistent wetness of air associated with long exposure to temperatures near to the dew-point is to a large extent responsible for the development of the disease.

The flare-up in disease could not be related to any earlier rainfall, and five weeks earlier only 0.56 inches of rain fell at widely scattered intervals in the relevant 35-day period. However, the plants were kept damp by persistent mists during the first 30 days of this period.

Disease-rate is expressed as a percentage. It is obtained by dividing the total number of diseased buds harvested by total bud production, that is flowers and diseased buds. Throughout the season never less than one hundred and nearly always more than two hundred buds were involved in the weekly counts. To make sure that percentage measurements were not misleading and that chilling, which is responsible for bud stimulation, was not involved in the relationship, a multiple regression of total bud production, healthy flowers and diseased buds on temperature 5 weeks earlier and 13 weeks earlier was examined in detail. The results, as might be expected, showed a very significant relationship between the disease-bud count and degree-hours spent below 50°F., 5 weeks earlier; and another equally very significant relationship between total bud production and degree hours spent below 60°F., 13 weeks earlier. The cold, misty spell, which caused the flare-up in disease 5 weeks later, was responsible for the flush of flowers which appeared 13 weeks later. Many Pyrethrum growers in East Africa seem to be faced with a difficult problem. The plants must be chilled to start bud development yet the chilling temperatures needed are not much above dew-point, so that there is little scope for bud-stimulation without simultaneous occurrence of climatic conditions favourable to the disease. Fortunately, it would seem that persistent recurrence of very high humidies or actual dew are needed to start a flare-up in the disease, and these are only rarely encountered; but, night after night, temperatures at or very close to dew point are encountered even if only for a few hours, and this together with the slow drying of the well-sheltered clump undoubtedly helps to maintain the disease even if only at a low level.

Plant Nutrition

Grasses were grown in sand culture for the Animal Industry Division. Growth measurements confirmed the importance of the nitrogen/phosphorus balance as reported for maize and sorghum in previous years. Pyrethrum has been established in sand culture.

A study of the comparative values of rapid biological and chemical tests of soil fertility has been started.

Reliability of rainfall (in conjunction with the Statistical Section)

During the year the reliability of seasonal rainfall in Tanganyika has been calculated and a preliminary draft map has been prepared. Similar maps for Kenya and Uganda have yet to be done. The extraction of bulk data has been slow because of lack of assistance. Thanks are due to the East African Meteorological Department for providing us with the bulk data for Tanganyika.

Much time has been spent answering enquiries about the reliability of rainfall in selected areas. Most of these come from territorial Departments who are concerned with the planning and future development of agricultural schemes.

A short course on the method of measurement of reliability was given to a group of Agricultural Officers selected by the Department of Agriculture, Kenya. It was prefaced by a short talk on the atmospheric circulation over East Africa which was given by the Assistant Director of the East African Meteorological Department.

Copies of the maps of the reliability of annual rainfall at two selected levels were presented to the Royal Commission. They were accompanied by a short memorandum concerning their relevance to future agricultural development.

Forestry

Staff

A. L. Griffith ..... *Silviculturist*
B. E. St. L. Stuart ..... *Assistant Silviculturist*
W. B. May ..... *Horticulturist*

Work has continued on the lines described in the 1952 Report. Particular attention has again been given to softwood nursery problems, to the development of Muguga estate for short-term and long-term experimental work, and to building up the Forest Bureau.

Forest Bureau

The Bureau now contains 1,361 tree-species files and 526 general information files. Over 100 enquiries were dealt with during the year. Further work has been done on compiling the East African forest bibliography.

Nursery Problems

The experiments begun in 1952 were completed in March, and the results assessed in conjunction with those of 1951. These experiments are being repeated and extended in scope in 1954; but since our experimental year in the nursery ends in March, the results of experiments begun in 1953 are not yet available. The following is a brief account of the experiments carried out so far.

Alteration of the pH value of the soil:—Experiments were laid down in 1951 with *Cupressus lusitanica* and *Pinus radiata*, and in 1952 with *Pinus radiata*, *P. patula*, and *P. engelmanni*. It was considered possible that by increasing or decreasing the soil acidity, a marked improvement in growth rate might be secured. In the first treatment, the pH of the soil was reduced from 6.0 to 4.5 by the application of dilute sulphuric acid. In the second treatment, a heavy agricultural-practice application of lime 1½ ozs. of ground limestone per transplant box) was made. Both treatments caused a retarding effect on height-growth with all the species tried in the two years, and the experiments will be discontinued.

Soil mixtures:—Experiments were carried out both in 1951 and 1952 with the object of finding out the best proportions of ingredients with which to standardise a nursery soil mixture. In 1951 the species used was *Cupressus lusitanica*, and in 1952 *Pinus patula*, *P. montezumae* and *P. engelmanni*. Six soil mixtures were prepared, consisting of various combinations of nursery soil, forest soil, chopped turf, pine soil, sand and vermiculite. The results were compared with those obtained with plants grown in the existing nursery soil. The mixtures gave striking increases in height-growth over the untreated nursery soil, particularly with the pines. Taking all three pines together, the best mixture gave an increase in height-growth of 59 per cent.

Similar techniques to improve soil structure, with local modifications, are likely to prove very beneficial in nurseries in the territories, especially those with a very fine volcanic dust.

Pine soil experiments:—Wide differences of opinion still exist on the need to add soil from pine plantations to nursery boxes and beds in which pines are raised, to inoculate them with the mycorrhiza-organisms said to be essential for their proper growth. Two experiments were started in 1952 and are being repeated. It should be noted that we have as yet not been able to test the fungal or bacterial content of the pine soil used, nor is this done by any forest station that advocates the use of pine soil.

We have so far tried four mixtures, on *Pinus radiata* and *P. patula*. The mixtures were 100 per cent pine soil, 50 per cent pine soil and

50 per cent indigenous forest soil, 100 per cent indigenous forest soil, and 100 per cent local nursery soil (previously under wattle). With both species, the pine soil and mixed pine and indigenous forest soil gave poorer results than the indigenous forest soil and nursery soil. Where fertilisers were used, the depressing effect of the pine soil was less, but still present. Poor structure of the pine soil used may be a partial explanation of the effects observed. The experiments will be repeated, including the incorporation of only small quantities of pine soil into a good soil mixture. If there is anything in the inoculation hypothesis, a small admixture of pine soil should be sufficient.

Fertiliser experiments:—The fertilisers used were sulphate of ammonia, triple superphosphate of lime, and sulphate or muriate of potash. All combinations of N, P. and K. were tried. In 1951, N was applied at the rate of 106 lb. fertiliser per acre, P at 108 lb. per acre, and K at 54 lb. per acre. On the advice of Dr. Crowther of Rothamsted, the amounts were stepped up in 1952 to 5 and 10 times these rates. The species used in 1951 were *Cupressus lusitanica* and *Pinus radiata;* in 1952, *Pinus radiata, P. patula*, and *P. engelmanni.* In one set of experiments, applications of fertiliser were made six weeks after the plants were pricked out: in a second set they were made twelve weeks after pricking out. The earlier application produced the better results. Still earlier applications, the P and K being mixed with the soil before planting and the N added very soon afterwards, are now being tried. With the highest rate of fertiliser application, there was an average increase in height-growth for the three pines taken together of 25 per cent using N, 29 per cent using P, and 25 per cent using K. With all three fertilisers together, the increase was 33 per cent. The lowest rates of fertiliser applications produced generally similar results but the increases in growth were less marked. Generally improved colour and vigour were obtained with the fertiliser treatments.

Use of gum arabic to reduce transpiration:—It was thought that spraying transplants with gum arabic solution after planting out might reduce transpiration and help the trees to get over a dry period after planting. Sets of plants eighteen months old were sprayed with 10 per cent and 5 per cent solutions of gum arabic in water. They were planted out, together with unsprayed plants, in a very dry period in January, in a dry bed. Each plant was given one gallon of water after planting but no shade. An assessment in March, after very little rain had fallen for eight weeks, showed that the sprayed plants had not benefited materially. Percentage survival for both sprayed and unsprayed plants was over 70 per cent.

The results of these experiments can only be accepted with caution until they have been repeated for several years.

Work has also been carried out by the Horticulturist on grafting pines and cypresses with a view to establishing seed orchards, on vegetative propagation of cypress, and on germination methods for use with difficult species. The nursery has been extended and a new store is under construction.

Nursery Course

A second course on the basic principles of forest nursery work was held at Muguga from 8th to 18th November. It was attended by 17 forest officers and foresters from Kenya, Uganda and Tanganyika. The course was run on the same lines as last year's and included both practical work and theoretical discussions, and visits to Kenya nurseries and plantations. A course of this kind is by far the best means we have of bringing the results of recent work on nursery techniques to the notice of field officers in the forest departments, and forms an excellent opportunity for the exchange of ideas and discussion of problems that require investigation.

Visits

The Tanganyika Forest Rangers' School paid us a visit for a week in March. Nursery and plantation techniques were demonstrated and discussed and visits made to Kenya nurseries and plantations.

Short-term Planting-out Problems

A small experimental garden was established during the year for short-term experiments to study planting techniques. These experiments form the intermediate step between nursery experiments and long-term experiments in the field. In many cases present techniques are determined by prejudice, rather than by experimental evidence. Eighteen experiments have been started in 1953 and will be repeated for some years. They cover the following subjects:—

Best age and size of transplant. (*Pinus patula, P. montezumae, Cupressus lusitanica, C. arizonica*).

Different types of soil preparation. (*Pinus patula*).

Different types of weeding. (*Pinus patula*). Effect of root pruning in the nursery on subsequent establishment. (*Pinus patula*).

Relative success of plants raised in boxes, in Swaziland beds, and earth blocks. (*Pinus patula, Eucalyptus sideroxylon*).

Comparison of direct sowing, transplanting and stumping (where applicable). (*Pinus patula, Cupressus arizonica, Ulmus parvifolia, Fraxinus americana, Eucalyptus saligna*).

These experiments will be assessed in terms of height-growth and survival percentage for each treatment, in March 1954. It is already clear that direct sowing has failed with all species tried. A few seeds germinated but the plants failed to survive the subsequent drought. Sowing in April was also probably too late.

Long-term Problems

A start has been made with the establishment of plantations on the estate for use in such long-term experimental work as sample plots, thinning experiments, etc. About twenty acres, mainly of

Pinus patula, were planted at the beginning of May, and in spite of poor rains, survival is on the whole satisfactory.

A new sample plot of *Eucalyptus saligna* has been demarcated in the 10-year-old crop flanking the main approach road through the estate.

Arboretum

Small trial plots of another 48 species have been successfully planted this year, which brings the total of plots up to 71. These include 14 cypresses, 17 pines, 14 eucalypts and 26 other species. Crop heights for a few of the more important species planted in 1952 are now (about 18 months after planting) as follows:—

	Feet
Eucalyptus saligna (Kenya seed)	17
Casuarina equisetifolia	11
Syncarpia laurifolia	8
Cupressus benthamii	7
Cupressus lusitanica	6
Pinus radiata	5
Pinus patula	4

In twenty plots a series of trees is being measured weekly to give an indication of when the various species grow and whether growth can be correlated with any particular meteorological conditions. From a study of those plots that have been under measurement since they were planted in April 1952, it appears that growth is remarkably steady throughout the year. There was, however, a well-marked increase in the rate of growth in November 1952, with the onset of the short rains, when the trees really began to grow for the first time. A decrease in rate of growth took place towards the end of the dry season in March, but only in a few cases did it cease altogether. There was a resumption of the previous rate of growth in April with the long rains, and thereafter growth remained steady for most species for the rest of the year. This year the rains have been light and there was practically no cold mist season after the long rains. Next year's growth pattern may not be the same.

The three plots of *Cupressus lusitanica* planted in April 1952, are of particular interest since they were grown from seed of selected trees, sorted into groups of seedlings with 2, 3 and 4 cotyledons after germination. It seemed possible that one of these groups might show better vigour or form or both in their future growth. At present, all three plots are about 6 feet high and no difference can be detected between them, although within each plot there is great variation between individuals, due probably to hybridisation.

Muguga Estate

Further wattle plantations have been cleared for the Arboretum, experimental garden, and long-term experiments. The *Eucalyptus saligna* plantations have been thinned, and a further 20 acres planted

for future fuel supplies. Many of the existing wattle plantations are in urgent need of thinning and this will shortly be carried out on contract, since we have not at present the resources to do this work ourselves. There have been some further cases of theft during the year, and some minor fires during the dry season, but little damage was done. Some 8 acres at the north-east corner of the estate were demarcated and handed over to the Kenya Forest Department in exchange for the Plant Quarantine Station site.

Conferences

During the year E.A.A.F.R.O. joined the International Union of Forest Research Organisations. The silviculturist attended the Eleventh Congress of I.U.F.R.O. in Rome during September and October. This conference was followed by a study tour of afforestation and soil conservation in Sicily. I.U.F.R.O. is interested in subjects of great importance to East Africa, notably seed orchards, the introduction of exotic species and soil conservation. Valuable information was obtained on these subjects.

Forest Entomology

STAFF

J. C. M. Gardner ..... *Forest Entomologist*

There has been no increase in the subordinate staff, which is well below the requirements of efficiency. The completion of a separate insectary has improved the facilities for experimental work.

CO-OPERATION WITH THE THREE TERRITORIES

Kenya.—A Forest Entomologist (Mr. S. J. Curry) was appointed early in the year and Mr. J. O. Evans continued to act as Insect Forester. However, the research work of both these officers was greatly hampered by special duties in connection with the Emergency. It is probable that, subject to the approval of the Chief Conservator of Forests, Kenya, the two officers and the Forest Entomologist of E.A.A.F.R.O. will work together as a team with a clear-cut programme of work.

Uganda.—The two African forest rangers, who had received an insect training under Mr. Gardner in 1952, continued to collect information. They have also carried out one or two special investigations. Several forest officers have sent in material and information of considerable interest; and it may be emphasised that the value of these data, which are duly recorded, is very great. The Uganda Forest Department has recently expressed interest in a home-made booklet issued in January, 1952, for use of forest rangers. It is hoped to improve upon this information service should there be sufficient demand from all three territories.

Tanganyika.—Michael Kangeri, Mr. Gardner's African assistant, visited Arusha in May for one month to give two recently-appointed Africans instruction in collecting information. No material has yet been received from them. Apart from some interesting items of information from individual forest officers, little is known of the forest insects of this territory.

Survey of Forest Insects

In view of the very few men working on forest insects in this very large area, the project is making quite good progress. Observations are gradually becoming more critical as notes on economic importance, factors predisposing to attack, and so on, are recorded in most cases. Quite a fair proportion of the insect species recorded may be regarded as beneficial, in so far as they seem to confine themselves to attacking trees not desired in the forest (weed species).

At the risk of tedious repetition, forest officers are invited to supply more information on special cases. Reports received so far have been very well done, but they have been few.

Intelligence Service

Records.—A mass of information requires ledger-filing and this will be a whole time task for additional staff. Card-indexing, however, is up-to-date.

Reference Collection of Insects.—This is increasing satisfactorily with the aid of the Commonwealth Institute of Entomology. Some of the numerous new species discovered have already been described by specialists.

A particular point is the building up of a collection of identified larvae. Our collection of larvae of the important family *Cerambycidae* has been sent to the British Museum and will form a large proportion of the material upon which Mr. E. A. J. Duffy will base his monograph on the African larvae of this family.

Special Problems

Oemida gahani Distant.—A summary of our knowledge of this major pest in Kenya has been published (Gardner and Evans). It was recently recorded near Arusha in Tanganyika by Mr. Gardner's African assistant.

Borers in Seasoned Wood.—Considerable interest has arisen in this subject, which is under the notice of the Timber Advisory Board to which Mr. Gardner acts as an adviser. Chemically impregnated wood is already available in Kenya.

Systematic Botany

Staff

P. J. Greenway ..... *Botanist-in-Charge*
B. Verdcourt ..... *Botanist*
Count A. E. Starzenski ..... *Scientific Assistant*

There has been a full complement of the Herbarium staff throughout the year. Among the many visitors were Prof. W. H. Pearsall, F.R.S., University College, London, Prof. Dr. Robyns, Director, Jardin Botanique de l'Etat, Brussels, Dr. Edna M. Lind, Makerere College, Kampala, Prof. Robert E. Fries, Institute of Plant Ecology, Uppsala, Sweden, Messrs. J. B. Gillett, J. H. Hemsley and R. B. Drummond, who worked in East Africa for a year on the *Flora of Tropical East Africa*, and Dr. B. Steele, Tsetse Botanist, Department of Game Fish and Tsetse Control, Nyasaland, who spent a month in the Herbarium studying the plants from his region.

Editorial help, identifications, etc., were provided for two books: A Descriptive List of the Introduced Trees of Uganda' by I. R. Dale, and 'Some Useful Plants of Nyasaland' by Mrs. G. Williamson.

The manuscripts of the families Onagraceae, Trapaceae, Hypericaceae, Pedaliaceae, Turneraceae and Chenopodiaceae for the *Flora of Tropical East Africa* were received from Kew for checking and general comments.

The Herbarium

In the course of the year 272 accessions of material were received, comprising over 5,600 specimens for naming, 2,000 named and 240 loaned for study.

The more important of the un-named collections were from:—

Arabia.—Desert Locust Survey, 120 (G. B. Popov).

Ethiopia.—Desert Locust Survey, 87 (A. C. Ashall).

Kenya.—Agricultural Department, 185 (A. Bogdan, Mrs. Nattrass); The Coryndon Memorial Museum, 10 (J. G. Williams); African Land Utilization and Settlement Board, 24 (G. D. Patterson); E.A.A.F.R.O., 237 (N. R. Brockington, V. F. Eastop, W. A. Sands, H. H. Storey, B. E. St. L. Stuart, E. C. Trump and W. Wilkinson); East African Herbarium, 670 (P. J. Greenway, H. Padwa, B. Verdcourt and G. Williams); E.A. Tsetse and Trypanosomiasis Research and Reclamation Organization, 54 (P. E. Glover); Kenya High School, Nairobi, 22 (P. L. D. Wood); Forest Department, 214 (M. C. Argyle, D. D. Darling, W. G. Dyson, H. H. C. Pudden and J. T. Templer); H. Grahame Bell, 38; Pest Control (E.A.) Ltd., Ruiru, 182 (van Someren); and sundry private collectors, 275.

Northern Rhodesia.—Entomological Laboratory, 2; Red Locust Control, 29 (A. A. Bullock and L. D. E. F. Vesey Fitzgerald).

Nyasaland.—Agricultural Department, 4 (Mrs. J. Williamson); E.A.A.F.R.O., 48 (W. A. Sands and E. C. Trump).

Socotra.—Desert Locust Survey, 323 (G. B. Popov).

Somalia.—Desert Locust Survey, 223 (C. F. Hemming).

Tanganyika.—Agricultural Department, 279 (N. R. Fuggles Couchman, E. A. Hubbard, J. D. Hunter Smith and F. Smith); E.A.A.F.R.O., 8 (D. L. Jennings); E.A. Herbarium, 40 (P. J. Greenway); E.A. Medical Survey and Filariasis Research Unit, 16; Forest Department, 1,240 (W. Carmichael, D. B. Davies, W. J. Eggeling, J. F. Hughes, R. D. Nightingale, M. S. Parry, S. Paulo, J. E. A. Procter, S. Semsei, G. Watkins, L. G. T. Wigg and R. L. Willan); Geological Survey, 123 (G. P. Leedal); Government Chemist, 43, native medicinal and poisonous plants; Overseas Food Corporation, 171 (B. Anderson, H. W. Brzostowski and J. D. Lea); E.A. Tsetse and Trypanosomiasis Research and Reclamation Organization, 32 (J. R. Welch).

Uganda.—Agricultural Department, 8; E.A.A.F.R.O., 52 (N. R. Brockington and E. C. Trump); E.A. Herbarium, 119 (B. Verdcourt); Forest Department, 499 (I. R. Dale, H. C. Dawkins and H. A. Osmaston); Hydrological Survey, 33 (E. M. Norman); Makerere College, 52 (Edna M. Lind).

Most of the material loaned to the Herbarium consisted of members of the Rubiaceae for study by Mr. B. Verdcourt.

The named material consisted of about two thousand specimens, received mostly in exchange: Institut National Etude Agronomique de Congo Belge, Yangambi, 40; Division of Botany, Department of Agriculture, Ottawa, Canada, 43; Grassland Research Station, Kitale, Kenya, 662, the majority being grasses collected and named by Mr. A. Bogdan; Royal Botanic Gardens, Kew, 660, mostly of Mr. J. B. Gillett's collecting in the N.F. Province, Kenya; Imperial Forestry Institute, Oxford, 132; Division of Botany and Plant Pathology, Pretoria, South Africa, 459.

Over ten thousand specimens were distributed from the Herbarium to botanical institutions overseas; of this over four thousand five hundred sheets comprising the families Caryophyllaceae, Chenopodiaceae, Cucurbitaceae, Loganiaceae, Menispermaceae, Podostemonaceae, as well as the genera *Albizzia*, *Indigofera*, *Lotus*, *Medicago*, and *Tephrosia* were sent to the British Museum, Brussels Botanic Gardens and the Royal Botanic Gardens, Kew, on loan for specialists to study in preparation of these families for the *Flora of Tropical East Africa*. Ninety-four sheets of *Diospyros* and *Maba* were loaned to Mr. F. White, Imperial Forestry Institute, Oxford, for his monograph on these genera. Dr. Raymond Hamet is continuing his studies of the Crassulaceae and a further sixty-four sheets of the genera *Kalanchoë* and *Sedum* were loaned to him.

In an attempt to straighten out all the *Eucalyptus* species in cultivation in East Africa, and in the E.A. Herbarium, material of this genus is being loaned to Mr. R. Johnston of the Forestry and Timber Bureau, Canberra, Australia, and a further one hundred and thirty-five sheets have been sent to him for re-determination.

The very interesting collection of nearly four hundred plants made by Mr. G. B. Popov of the Desert Locust Survey on the Island of Socotra was named as far as possible and a duplicate set was sent to the British Museum.

Requests for plant material continue to be received from all parts of the world and the following was distributed:—*Burttdavya nyasica,* Prof. J. W. Cook, Glasgow University, Glasgow, Scotland; *Phyllanthus engleri,* and *Momordica* spp., The Royal Botanic Gardens, Kew; *Momordica cardiospermoides,* The Government Chemist, Dar es Salaam, Tanganyika; *Rauvolfia vomitoria,* Messrs. S. B. Penick & Co., New York, U.S.A.

Over five thousand six hundred plants were named. Information was supplied and questions answered on a wide range of subjects, not only to government departments and private individuals in East Africa but to other parts of the world.

In the course of naming collections and amalgamating the two herbaria a further 29 type specimens were found. The following new species were described from the Herbarium:—

Acacia senegal (L.) Willd. var. *leiorhachis* Brenan (Mimosaceae) in *Kew Bull.,* 1953, p. 98. *Greenway* 2192! isotype.

Adinandra greenwayi Verdcourt (Theaceae) l.c. p. 84 (1953). *Greenway* 6556! isotype.

Lobelia melleri Hemsl. var. *grossidens* E. Wimm. (Lobeliaceae) l.c. p. 139 (1952) *Lugard* 149! isotype.

Oldenlandia aegialodes Brem. (Rubiaceae) l.c. p. 438 (1953). *Greenway* 5236 sic, 5216! isotype.

Parapentas battiscombei Verdcourt in *Bull. Jard. Bot. Brux.,* 23, p. 54 (1953). *Battiscombe* 695! holotype.

Phyllanthus trichotepalus Brenan (Euphorbiaceae) in *Kew Bull.,* 1953 p. 92. *Purseglove* 3403! isotype.

Primularia pulchella Brenan (Melastomaceae) l.c. p. 88 (1953). *Eggeling* 6041! isotype.

Salsola dendroides Pall. var. *africana* Brenan (Chenopodiaceae) l.c. p. 433 (1953). *Bally* 2011! isotype.

Sesamum latifolium Gillett (Pedaliaceae) l.c. p. 118 (1953) *Thomas* 3708! isotype.

Suaeda micromeris Brenan (Chenopodiaceae) l.c. p. 432 (1953). *Glover & Gilliland* 119! isotype.

Trifolium cheranganiense Gillett (Papilionaceae) l.c. p. 373 (1952). *Rawlins* 2! isotype.

T. masaiënse Gillett, l.c. p. 387 (1953). *Hornby* H40/32/16! isotype.

T. purseglovei Gillett, l.c. p. 383 (1953). *Purseglove* 3139! isotype.

T. rueppellianum Fres. var. *minimiflorum* Gillett, l.c. p. 390 (1953). *Haarer* 353! isotype.

T. semipilosum Fres. var. *glabrescens* Gillett, l.c. p. 386 (1953). *Greenway* 7871! isotype.

These fifteen new species together with the twenty-nine recently found now brings the total number of known types in the Herbarium up to 685.

A total of 5,255 specimens were filed into the Herbarium during the year; this includes 1,235 specimens comprising nine families transferred from the Coryndon Memorial Museum Herbarium. Of the latter 426 were grasses, bringing the grass collection up to 9,491 sheets and the grand total for the herbarium to 84,483.

Books and separates were loaned to various correspondents and thirty-six vegetation and plant photographs were loaned to the Editor of the *Tanganyika Handbook* for the second edition.

The amalgamation of the Coryndon Memorial Museum Herbarium continues intermittently; as we are finding it difficult to keep pace with the accessions and the day-to-day routine with which we are confronted.

Field Work

Mr. Gillett, Colonial Office Botanist, with the African Assistant. Hanery Padwa, returned to Nairobi towards the end of February from the Northern Frontier Province and Ethiopia, where, attached to the Kenya-Ethiopia Boundary Commission, he had been working for about a year.

Messrs. Hemsley and Drummond from Kew arrived in Mombasa in January and began collecting in the vicinity. Later, they left Nairobi for seven months field work, visiting the Northern, Tanga and Eastern Provinces of Tanganyika, and, more briefly, the Eldama Ravine and Kakamega areas of Kenya, the Eastern and Buganda Provinces of Uganda, and the Bukoba District of the Lake Province of Tanganyika. The African assistants, Edward Kirrika and George Williams, helped in this work.

In May and June Hanery Padwa accompanied Mr. J. G. Williams, Ornithologist, Coryndon Memorial Museum, to Lake Rudolph and the

south-eastern borders of the Sudan during his ecological investigations of the Dioch bird, *Quelea quelea aethiopica*. Although this area is botanically unexplored, only a few new or outstanding plants were found in the 295 specimens collected.

Thanks are due to Dr. W. J. Eggeling, Chief Conservator of Forests, Tanganyika, and to members of his staff in the Northern, Tanga and Eastern Provinces for help given to Messrs. Greenway, Hemsley and Drummond during their visits, and to Mr. J. G. Williams of the Coryndon Memorial Museum for supervising the work of the African collector whilst on safari in north-western Kenya and south-eastern Sudan.

Systematic Zoology

B. Verdcourt

Collections of *Meligethes* beetles have been continued for Dr. Easton and the number of species to be described is now in the neighbourhood of 20. The genus was previously practically unknown from E. Africa.

The study collections of mollusca (both marine and non-marine) in the Coryndon Memorial Museum have been overhauled. A special collection of cowries has been started by request, and an article on the E. African species is in the course of preparation.

Numerous mollusca have been named for various private persons and government departments during the year.

Soil Microbiology

Staff

J. Meiklejohn ..... *Microbiologist*
(Seconded from Rothamsted Experimental Station)

Dr. Meiklejohn left for England in August, at the end of her secondment from Rothamsted. During the eight months of 1953 work was continued along the lines started in 1952.

Nitrification

Laboratory tests made on soil from the nitrate-accumulation experiment at Kawanda gave results which were very difficult to interpret. In the field it had been found that more nitrate accumulated in bare fallow exposed to the sun, than in fallow shaded or covered with a grass mulch. But in the laboratory the cultures of nitrifying bacteria derived from the unshaded soil were far less active than those from the shaded and the mulched soils. The nitrifying bacteria had a temperature optimum of about 30°C., which was much lower

than the temperatures reached at the surface of exposed soil; and they grew better at pH 7 than at pH 5.4, though the pH of the Kawanda soils was about 5. This last result might perhaps have been expected, since in the field the addition of limestone to bring the soil pH to 7 made no differece in the rate of nitrate accumulation. These results have been reported in a paper read to the Fertiliser Conference, February 1952, and published in the *East African Agricultural Journal*.

New field experiments on nitrate accumulation, more simply designed than the Kawanda experiment, were set up in 1953 by the Uganda Department of Agriculture. Soil samples were taken in July and examined for nitrifying bacteria. These appear to be present in the three more fertile soils, from Bukalasa, Nakabango and Kawanda, but are few or absent in the less fertile soils from Serere, Ngetta and Entebbe. It is to be hoped that this work will be followed up when a new Soil Microbiologist is appointed.

Bush Burning

Very little is known of the effect of bush burning on the soil, although it is a widespread farming practice in the tropics. The opportunity was therefore taken to study the changes in the microflora produced by burning, when newly-cleared land was being burnt over on the farm at Muguga in the early months of 1953. Burning reduces the number of microorganisms in the topsoil, whether counted by a direct method or by plating methods. The reduction in the number of fungi was particularly marked, and the fungi were temporarily killed off on two of the three sites examined. Aerobic nitrogen-fixers were also killed by the burning; anaerobic nitrogen-fixers survived, but were not very effective, either before or after burning. Nitrifiers were either killed, or very greatly reduced in numbers, by burning.

Total nitrogen determinations, done by the Chemistry Section in April and again in August, showed that there was more nitrogen in the soil from burnt than from unburned patches on all three sites on both occasions. This may possibly be due to the destruction of the nitrifiers by burning, as, if nitrate is formed, nitrogen may be lost by denitrification or by leaching.

Numbers of Microorganisms in Soil

Few counts have been made of the numbers of microorganisms in tropical soils, and none by modern methods; so, some counts were made on soils from the Muguga Farm, both on the burnt sites, and on an arable field that carried wheat in 1952 and potatoes in 1953. The new Direct Count method devised at Rothamsted gave numbers of the same order, 1,000 million to 3,000 million cells per gram of dry soil, as had been obtained in counts made by Skinner, Jones and Mollison on Broadbalk Field at Rothamsted. Plate counts showed very small numbers of fungi, the highest count being only about 100 thousand per gram. The number of actinomycetes, on the other hand, was very high, exceeding the number of bacteria in most samples.

Types of Nitrogen-fixing Bacteria

The classical aerobic nitrogen-fixer of temperate soils, *Azotobacter*, was looked for in the Muguga soils, but was never found. There are nitrogen-fixers in the Muguga soils, but none of them fixes nitrogen in any great quantity in culture. Most of those obtained appeared to be species of *Clostridium*, a spore-forming genus.

Impure cultures of *Azotobacter*, which is easily identified by the large size of its cells, were obtained from a calcareous soil from Vipingo, on the coastal plain, forwarded by Dr. Leutenegger of the Sisal Research Station, Mlingano, Tanganyika. A most interesting organism, which seems to be a species of *Beijerinckia*, was isolated from an acid sandy soil sample also sent by Dr. Leutenegger. This bacterium is an active nitrogen-fixer, and the fact that it occurs in an acid soil may help to explain why many acid soils in East Africa are quite fertile. Cultures of this organism have been taken to Rothamsted for further study.

Soil Chemistry

Staff

H. F. Birch ..... *Chemist*
G. T. Chamberlain ..... *Spectrochemist*
M. T. Friend ..... *Analyst*
P. R. Hesse ..... *Chemist*
M. Maclean ..... *Scientific Assistant*

The work done during 1953 is discussed under the following headings:

(1) Soil and miscellaneous analyses.

(2) Soil phosphate and fertility studies.

(3) An investigation of the physical and chemical characteristics of termite mounds.

(4) Spectrochemical investigations.

Soil and Miscellaneous Analyses

M. T. Friend

Soil Survey Section:—496 soils were analysed for pH, nitrogen, carbon, sand, silt, clay and moisture.

Fertiliser Schemes:—379 soils from various fertiliser trials were analysed for pH and three forms of phosphate and 49 for pH, nitrogen, carbon, sand, silt, clay and phosphates.

Wheat Investigation (see below):—120 soils were analysed for pH, carbon, nitrogen, sand, silt, clay and phosphate.

Advisory Work:—55 samples were analysed mainly for pH, nitrogen, carbon, sand, silt and clay. In addition 10 soil samples and 10 water samples from British Somaliland were analysed for soluble salts, pH and carbonates, to help the Department of Agriculture in the establishment of plantations and in irrigation schemes.

Plant Analyses:—71 groundnut samples from the O.F.C. were analysed for phosphorus and nitrogen, and 81 pyrethrum samples from fertiliser trials in the S. Highlands, Tanganyika, were analysed for phosphorus; 6 samples from the Specialist Committee on Animal Industry were analysed for phosphorus, nitrogen and moisture.

Bacteria:—130 samples of N-fixing bacteria were analysed for total N for the Soil Microbiologist.

The total number of determinations made was 8,117. In addition, exchangeable bases were determined on many of the soil samples (see Spectrochemical report).

Phosphate and Soil Fertility Investigations

H. F. Birch

Following the establishment of the relationship between phosphate response and base saturation or pH of the soil, data are now being accumulated from field experiments laid down by the Departments of Agriculture in Kenya and Tanganyika, to find out to what extent the relationship is of general application. Moreover, while phosphorus appears to be the most important factor limiting yield in East African soils, nitrogen also plays a fairly important part; and attempts are now being made to relate nitrogen responses with soil characteristics.

With regard to phosphate responses, an analysis of the yield data from exploratory fertilizer trials laid down by the Department of Agriculture, Kenya, in Central and South Nyanza showed a very significant relationship between percentage response to phosphate and pH for millet (9 observations, $P=0.01$), a less significant relationship for sorghum (10 obs. P between 0.1 and 0.05), and a non-significant relationship for maize (10 obs.).

A study of nitrogen-response data from the Highland Fertiliser Scheme experiments has been made, but no significant relationship was found between response and any of the soil characteristics measured (pH, carbon, total nitrogen, bases, sand, silt, clay and phosphate). Presumably none of these, including total nitrogen, is related to available soil nitrogen. A soil analytical method is therefore being sought that will better reflect the available nitrogen status of the soil. The problem of relating nitrogen response to soil characters has been complicated by the somewhat erratic behaviour of crops to nitrogen. In some experiments, for instance, a negative

response was obtained one year and a positive response the next, depending probably on the weather and the time and method of application of the nitrogenous fertiliser.

Preliminary work has been carried out on the extent to which soil factors may influence the desirable character of certain wheat varieties. This work is being carried out in conjunction with the Senior Plant Breeder, Njoro, and the Chief Chemist of Unga Ltd. The problem arose from observations in 1950 and 1951 that a single variety grown in different parts of the same area gave flours of different strengths, and also that the flour strength from one variety on the same plot varied from year to year. One of several factors to which this variability could possibly be ascribed was a difference in soil characters. As a preliminary test, 120 soil samples representative of the area in which the trials were laid down were collected in 1953 and analysed for pH, carbon, nitrogen, sand, silt, clay, bases and phosphate. There was no marked variation in these soil characters over the area. Since, however, the soil samples were collected two years after the trials it was not possible definitely to reject the possibility of soil characters influencing those of wheat. An experiment designed specifically to test this has therefore been drawn up, again in collaboration with the Senior Plant Breeder, Njoro, and the Chief Chemist of Unga Ltd.

The Soils of Termite Mounds

P. R. Hesse

This investigation was completed during the year. There is little to add to the main conclusions stated in last year's report except in connection with exchangeable bases.

It has been found that termite mounds tend to have a higher base-exchange capacity and to contain more exchangeable bases than the adjacent soils. Only the non-calcareous mounds were considered because the calcareous ones were, of necessity, fully saturated. These non-calcareous mounds showed high base contents whether they were in a very early stage of construction or old and derelict; nor did the size of the mounds appear to make any difference. The distribution of bases in any one mound was quite haphazard but on the whole was of the same order throughout. The total base content was, if anything, less in the queen's cell and fungus-garden chambers than in the bulk of a mound, except for exchangeable manganese which was often higher in these regions. All of the bases (calcium, magnesium, manganese, potassium and sodium) were higher in the mounds than in the adjacent soils. There is no relationship between the amounts of exchangeable bases found in termite mounds and either clay or organic matter contents. Similarly, there is no relationship between the average increase in base content of a mound over that of the subsoil and the base content of that subsoil. Thus the general conclusion is that all termite mounds tend to have a higher base-exchange capacity and to contain more exchangeable bases than their surrounding soils, regardless of their size, shape, age, whether or not they are inhabited or wherever they may be located.

In all other respects the soil of a non-calcareous termite mound is practically identical with the nearby subsoil; and the exchangeable base content is the only consistent difference in chemical characters that has been found. The high base content of a mound soil is, then, not due to an increased clay or organic-matter content—factors which normally govern the amount of bases in a soil. In fact, measurements have shown that, even when a mound has less clay and organic matter than its nearby subsoil, it still contains more bases. Also, as already mentioned, the queens' cells and fungus garden chambers, parts of a mound which are rich in clay, often contain less bases than are found in the rest of their respective mounds. As the mounds under consideration are those which do not accumulate material from the surrounding land, it was considered that the only factors that could be responsible for a high base content in termite mounds were:—

(a) The fungus comb.

(b) The termites' bodies.

(c) The termites' saliva during the building process.

(d) The differences in the structure of a mound soil.

Each of these possibilies has been investigated and each has been discarded as a reason for the phenomenon. Further experiments indicate that the kind of clay in termite mounds may differ from that in the adjacent subsoils. In order to establish whether or not this is so, clay samples have been sent to Rothamsted for X-ray analysis. Further work on this problem will depend on the results of these analyses.

Spectrochemistry

G. T. Chamberlain

The Lundegardh flame method has been applied to a wide variety of samples. With the Littrow spectrograph, time has been spent almost entirely in establishing the trace-element techniques, details being given below; but in addition, it has been possible with this instrument to give assistance to the Mines and Geological Department, Kenya, in the analysis of mineral deposits for the rare earths and other metals.

Flame Analysis

Technique.—The basic technique has remained unaltered, but opportunity has been found to carry out more experiments with the direct-reading potassium method. The results appear to be satisfactory, but further confirmation is required. It is expected that for plant materials this method will be adopted, the other major elements being determined by the arc method simultaneously with copper and iron.

Soil Analysis.—During the year, 954 soils were analysed for the acetate-extractable bases, this number being made up of 70 for the

Overseas Food Corporation, 15 for the Tsetse Department, Tanganyika, 291 for the Department of Agriculture, Kenya, 46 for the Forest Department, Kenya, and 532 for E.A.A.F.R.O. Sections. In addition to the above, some 35 soil acetate- and water-extracts were analysed for the termite soil investigations, and the water-soluble salts determined for 10 soils from the Director of Agriculture and Veterinary Services, Somaliland.

Plant and other analyses.—No further sisal analyses have been undertaken, but reference is made to this under "Advisory Work". In co-operation with the Animal Industry Division, 19 samples of animal feeding stuffs have been analysed, as the first stage in the production of a table of the mineral contents of these materials. Analyses have also been carried out on six samples distributed by the Specialist Committee on Animal Industry, to test the comparability of results obtained in various laboratories throughout East Africa.

For the Coffee Research Station, Ruiru, bases were determined in sixteen grasses from a fertiliser trial.

Ten well-water samples were analysed for the Director of Agriculture and Veterinary Services, Somaliland, 11 miscellaneous solutions for the termite soil investigations and two samples of natural waters (R. Uaso Nyiro and Buffalo Springs near Archers Post, N.F.P.).

Arc Analysis

Considerable progress has been made in the establishment of the trace-element methods, two of which are now in operation. The third method, employing chemical concentration, is almost ready for use. To achieve this, it has been necessary to purify and examine spectrochemically over sixty chemicals for the standard mixtures or for use as current reagents. In all, some 70 standard mixtures have been made up for carrying out calibrations for 19 elements (not including the rare earth determinations described below).

Boron Determination.—This method is based on a suggestion of Mr. G. Smith of Rothamsted Experimental Station. Standard mixtures containing 10-3000 p.p.m. boron in a base of mixed potassium, sodium and calcium salts were used for calibration. The plant ash was mixed with a buffer of ammonium sulphate and sodium chloride and burned in a pure copper electrode. The rotating step sector was used for calibration and the intensity ratio of the boron line 2497.7 to the tin line 2495.7 was obtained; tin was included in the buffer as the internal standard.

Copper, Iron, Manganese, Strontium and Barium.—The method for the determination of these elements is that devised at the Macaulay Institute for Soil Research, Aberdeen, and involves the burning of the plant ash with a buffer of potassium sulphate. Standard mixtures were made up containing copper 10-3000 p.p.m., barium and strontium 30-10,000 p.p.m., and manganese and iron 100-30,000 p.p.m., and relative line intensities found for these elements against the internal standards chromium and silver. The rotating step sector was again used. The method was tested with a few samples before proceeding with the concentration method.

Concentration method.—Most of the year has been spent on this method, which has required considerable care in the purification of chemicals and the preparation of standard mixtures, some 35 of which have so far been made up. This method also is one devised by the Macaulay Institute; the trace elements are precipitated from solution by the combination of three organic reagents, which permits their concentration from 20 grams of sample into about 50 milligrams of aluminium oxide. Part of this oxide mixture is burned in the arc using carbon electrodes and the relative intensities of spectrum lines of the trace elements to iron as internal standard are obtained. Owing to the iron content of the sample being variable, calibrations with standard mixtures must be carried out at several levels of iron content. So far, Fe_20_3 contents of 2 per cent., 2.5 per cent., 5 per cent., 7 per cent. and 10 per cent. have been dealt with over a trace element range of 10 p.p.m. to 1 per cent. A value of 10 p.p.m. in the concentrate is equivalent to 0.025 p.p.m. in the original sample. The iron content of the concentrate is determined by a colorimetric method and this method has also been established. This trace-element method is now at the stage where blank determinations on reagents and analyses of concentrates prepared at the Macaulay Institute are being carried out

Rare Earth Determinations

The Mines and Geological Department, Kenya, asked if we would measure the amounts of niobium, tantalum, thorium, titanium and the rare earth metals in certain mineral deposits. Three samples were examined and a report was given, but this was incomplete owing to the lack of knowledge of the rare earth spectra. The Mines and Geological Department then supplied the small quantities of "Specpure" oxides to enable standard mixtures to be prepared. In all, 22 mixtures were made up covering the following ranges of oxide contents: —

Erbium (Er_2O_3) and Dysprosium (Dy_2O_3) 0.0025 — 0.25 per cent., Ytterbium (Yb_2O_3) 0.005 — 0.5 per cent.; Samarium (Sm_2O_3), Europium (Eu_2O_3) Gadolinium (Gd_2O_3) and Tantalum (Ta_2O_5) 0.01 — 1 per cent.; Niobium (Nb_2O_5), Yttrium (Y_2O_3) and Scandium (Sc_2O_3), 0.02 — 2 per cent.; Praseodymium (Pr_2O_3) 0.025 — 2.5 per cent.; Lanthanum (La_2O_3), Neodymium (Nd_2O_3), Thorium (ThO_2) and Titanium (TiO_2) 0.05 — 5 per cent.; and Cerium (CeO_2) 0.15 — 15 per cent.

Two sets of standard spectrograms covering the wavelength ranges 8000-3200 A. and 3550-2430 A. were prepared and these enabled the semi-quantitative determinations of the above metals to be made.

Advisory Work

As previously arranged, Mr. J. F. Osborne of the Sisal Research Station, Mlingano, T.T., arrived at Muguga in April to undergo training in the Lundegardh flame method for the determination of the major elements in soils and plants. Mr. Osborne returned to Mlingano in July, and I visited the Sisal Station to assist in setting up the laboratory. Mr. Osborne is to return to Muguga during 1954 to learn the trace-element techniques.

Assistance was given to Mr. W. Langridge of the Tsetse Research Station, Kilifi, Kenya, on the building of an instrument to measure the spectral distribution of light in various fly areas.

Soil Physics

Staff

H. C. Pereira ..... *Soil Physicist*
P. H. Hosegood ..... *Scientific Assistant*

Progress in this Section has been handicapped very heavily this year by Police Reserve duties, which have occupied much of the time of both European and senior African staff. The main field measurements and laboratory studies have been maintained, but the time available for analysis of data and its preparation for publication has been seriously curtailed.

Some results, illustrating progress in the several lines of investigation, are outlined below.

Water Use of Catchment Area Vegetation

Measurements have continued under three alternatives for land use in the high-altitude catchment areas, i.e., indigenous bamboo forest, and an adjacent 16-year-old cypress plantation, at an altitude of 8,600 feet, and under permanent Kikuyu-grass pasture at 7,200 feet. The low rainfall of 1953, following the unusually poor November rainfall of 1952, resulted in a continuous soil moisture deficit in the first ten feet under all three types of cover. Under these conditions, percolation to deep ground water has been negligible and the whole of the rainfall can be accounted for by evaporation and transpiration and by changes in the soil moisture storage. The progress of the storage changes is followed by electrical resistance readings from buried gypsum units which are measured twice weekly, giving a "running commentary" on moisture conditions at over 120 points in the soil. The quantitative measurement of these storage changes is made by soil moisture sampling with a heavy winch-operated drill, and the samples are taken at times indicated as critical by the resistance readings. Sampling during 1953 has been carried out to 10 feet under the forest and plantation and to 15 feet under the pasture.

This forest area has been subjected to considerable Mau Mau disturbance, and a clash, involving some scores of casualties, occurred in the plantations containing these experiments. Very great credit is due to Mr. Gurdar Singh, a Senior Assistant Forest Officer of the Kenya Forest Department, and to his loyal Kikuyu staff, who continued to take the essential resistance and rainfall readings under very trying circumstances.

The measurements under bamboo and cypress were undertaken to obtain factual evidence for the resolution of a controversy concern-

ing land use in the high forested catchment areas. Suspicion that the quick-growing plantations of exotic softwoods might use up more water than does the indigenous bamboo, led to an administrative restriction on the Forest Department's programme of plantation development. Adequate evidence has now been obtained to show that these fears are without foundation. The data are being published in the scientific press but the facts are summarised briefly below:—

Comparison of cypress plantation with bamboo forest

1951 (Total annual rainfall 60 inches, measured in four standard 5-inch rain gauges).

In the first three months of hot dry weather the bamboo developed a greater moisture deficit in the fourth, fifth and sixth feet than did the cypress. Heavy rainfall from April onwards refilled the soil to field capacity, and maintained conditions permitting the downward percolation of water beyond six feet until the end of the year, when deficits again occurred. Conditions suitable for percolation beyond the main zone of concentration of both root systems continued for more than five weeks longer under cypress than under bamboo. During that time an additional five inches of rainfall occurred, so that the opportunities for transmission of water to deep storage were greater under cypress than under bamboo in this unusually wet year.

1952 (Total annual rainfall 38 inches).

Bamboo again developed a soil moisture deficit in the first six feet some $2\frac{1}{4}$ inches greater in quantity and over two months longer in duration than for the deficit under cypress. The soil was refilled by a "Long Rains" of 24 inches in six weeks during April and May. Sampling two weeks after the end of this rain, when rapid drainage had ceased and "field capacity" had been attained, the cypress was found to have retained $4\frac{1}{4}$ inches, and the bamboo 8 inches, out of the 24. Estimates for the year indicate cypress as taking 23 inches in evaporation and transpiration, while 15 inches passed beyond the six-feet depth: bamboo used approximately 27 inches and permitted only 11 inches to pass to deeper storage.

1953 (Total Annual Rainfall 30 inches).

In this very dry year conditions permitting percolation were not established under either cover. There was a small net loss of stored water within the first 10 feet during the year, so that evaporation and transpiration losses slightly exceeded the total rainfall under both covers. There was no significant difference between the water used by the two types of vgetation. The mean daily rate of water loss by evapo-transpiration was found between June 1952 and June 1953 to be approximately 0.075 inches per day. The rate for the cool dry weather of July to October was 0.06 inches per day, and that for the hot weather of November to March was 0.09 inches per day.

The results to date therefore show that in a very dry year both types of forest cover used all the available water and passed no rain water through to deep storage, while in wetter years the advantage

lay with the cypress plantation rather than with the bamboo. Since transpiration is greatly reduced during the clearing, planting, and early growth stages of the plantation, and again during felling and replanting, the overall advantage to river-flow on the replacement of bamboo by cypress plantations will be considerable.

Water use by Kikuyu-grass pasture

The root distribution of this valuable indigenous pasture grass (*Pennisetum clandestinum*) was studied by removing sample blocks of soil from the face of a large pit. Each block occupied a square foot of the pit face, and was six inches thick. Three profile sets of such samples were taken to a depth of 15 feet. The soil was crumbled by hand, and stirred by a hand operated water jet in a 4-gallon container, the overflow passing onto a 1mm. sieve. The soil was thus dispersed and the grass roots were retained by the sieve. Their volume was then determined by displacement of water. Although this method underestimates the real volume of roots, it is adequate to explore their distribution in the profile. Of the total volume of roots found in the profile, the percentage found in each foot is given in Table I.

TABLE I

DISTRIBUTION OF KIKUYU GRASS ROOTS IN A DEEP VOLCANIC SOIL

Depth in feet	*Cubic inches of roots per cubic foot of soil*	*Percentage of total roots*
0-1	45.06	60.0
1-2	9.98	13.3
2-3	5.20	7.0
3-4	3.29	4.4
4-5	3.45	4.6
5-6	2.84	3.8
6-7	1.77	2.4
7-8	0.84	1.1
8-9	0.67	0.9
9-10	0.48	0.6
10-11	0.22	0.3
11-12	0.22	0.3
12-13	0.31	0.4
13-14	0.39	0.5
14-15	0.31	0.4

The apparent concentration of roots in the top foot is due to the presence of thick stolons, and the relatively small volume of deep roots has been shown, both by the sampling and by the resistance readings, to be remarkably effective in the seasonal reduction to wilting point of the first 10 feet of soil.

This root study indicated that even deeper soil sampling was required for a full study of water storage changes, and the effects

of the long rains of April and May in 1953 were therefore measured by samplings to 15 feet. At this depth the number of profiles is seriously reduced, since two full days were required to obtain each set of samples to this depth, using 250 lb. weights on the drill rods, and a low-geared winch. The rains were poor, amounting to only 13 inches, which is about half the amount usually received in these two months. Although only the first four feet of soil were raised to a stable condition of field capacity, this rain penetrated to 10 feet at the top, middle and bottom of the hillside. Below 10 feet, the sampling gave interesting evidence of the lateral movement of water. While the water content of the 10 feet to 15 feet zone remained unchanged at the top of the hill, it increased by 10 inches at the bottom of the valley in mid-rains, and a week after the end of the rains had again decreased by 4 inches. This concentration of water in the subsoil can have occurred over only a small part of the valley bottom, and the total quantity of water involved must have been small, since most of the rainfall over the catchment was accounted for by the measured increase in soil moisture in the first few feet. It is interesting to note, however, that under conditions of fairly intense rainfall, some water succeeded in passing through four feet of soil which was below field capacity (by passing down old root-channels, insect burrows and soil cracks) and then concentrating by lateral movement through the wetter layers of deep subsoil. No runoff or streamflow has occurred from this 11-acre catchment basin during five years of experimental observations, although the owner of the land reports that a permanent stream existed until tall bush was replaced by Kikuyu-grass pasture.

Water use by crops and leys in rotations

A field study at Muguga, in co-operation with the Kenya Soil Conservation Service and the Animal Industry Division of Muguga has made satisfactory progress during the year. A slope of 12 per cent. has been cleared of wattle trees and stumped. Test pits showed no sign of past erosion, since the wattle plantation had followed indigenous forest, and its establishment and management had been in the hands of the Kenya Forest Department. Sixteen fields have been laid out, each protected by a cut-off drain. These fields are in randomised pairs, one being a standard terrace width and the second a slope having four times the vertical interval of the terrace. All sixteen fields discharge into V-section terrace channels, each 300 feet long, the terrace outlets being metered autographically through Parshall flumes. The larger field of each pair is of approximately one acre, the exact area of catchment being defined by broad low bunds over which tractor implements can be worked. The terraces were completed and carefully hand-corrected under the supervision of Soil Conservation Service staff. They were then planted with a short perennial grass (*Paspalum notatum*). The field surfaces were hand-corrected after stumping, and were worked level with tractor-drawn discs and harrows. All fields were sown to oats as a uniformity test-crop in November, and a very satisfactory and even stand has been obtained in spite of very dry weather. Casting of the concrete measuring flumes began late in the year. Twelve profile sets of cylindrical gypsum resistance units were placed to the 10 foot depth, and a further twelve will be placed during 1954. A separate hole was drilled for each unit.

Volumetric calibration of the soil profiles, by tension-table studies of soil cores taken from the sides of pits, have been carried out in the laboratory during the year. Periodic soil sampling to 10 feet in bare fallow was continued after the main rains of April and May in order to measure qualitatively the changes in soil storage in the absence of roots, before starting the crop rotations. Comparison of field sampling data with the tension-plate studies of soil cores confirmed that a tension of one-third of an atmosphere satisfactorily reproduces the moisture contents observed, in the absence of roots, in this deep volcanic clay subsoil, after rapid drainage has ceased.

Disturbed soil samples were also used for this comparison, the soil passing a 2 mm. sieve being poured into copper rings on the tension plates. Agreement with soil core determinations was usually good, but a number of puzzling exceptions were encountered, both with this lateritic clay soil and with lighter soils.

Water conservation by dry farming in Tanganyika

In this co-operative study with the O.F.C., of the soil moisture storage changes under two-year rotations at Kongwa, the cereal and fallow treatments of the first year received 22 inches of well-distributed rainfall and good crops were harvested. This year, 1953, was the second year, and all treatments carried groundnuts. Only 8½ inches of poorly-distributed rain were received, and although measurable crops were harvested on all plots, the yields were slight.

The soil moisture changes have, however, already provided useful information under these severe conditions.

The weedy fallows grew a heavy crop of grasses and herbs, which depleted soil moisture reserves as much as did a 10-bag crop of maize. A heavy sorghum crop, harvested by birds, left more water in the soil. The clean-tilled fallow, sampled seven weeks after the end of the 22-inch rain season, had conserved six inches of available water between the 1 foot and 6 foot depths. By the beginning of the 1953 rains after 6½ hot dry months, the whole of the available water had been lost by evaporation from the first foot of the bare fallows, together with most of the stored moisture in the second foot. Thus the water stored successfully to the end of the dry season in the first six feet of soil was approximately 4¼ inches, lying below the 2 foot depth. This water was stored however, at the cost of long exposure of bare cultivated surface soil to sun and wind, with an inevitable increase in liability to erosion.

The third of the fallow treatments provided evidence towards a promising solution of this difficulty. A short-season shallow-rooted annual grass was sown thickly on clean fallow at the beginning of the rains. Among several possible grasses *Teff* (*Eragrostis abyssinica*) was selected for ease of seed supply and for its value as grain and fodder. It grew sufficiently well to exclude weeds, while its roots penetrated less than two feet. At the end of the rains the soil moisture in six feet of soil under teff was only one inch less than that under bare fallow; the teff plots, however, entered the dry season with a useful protective covering. During the dry season, the bare fallow lost nearly one inch more water than did the teff, so that

both fallows effectively stored about 4 inches of water. Thus the protection of the teff was secured without reduction in the storage of water. Economic rates of sowing of this protective cover must be found if it is to be used in the extensive farming of semi-arid lands. Small-plot trials are therefore in progress at Muguga: in 1953, under a total rainfall of 22 inches, seeding rates below 45 lb. per acre failed to suppress indigenous weeds.

The test-crop of groundnuts, sown in 1953, showed a marked benefit from the stored water; after one month the plant survival was over 40 per cent on both the bare and the teff protected fallow treatments, while it was only 5 per cent after weeds, 16 per cent after maize and 30 per cent after sorghum. The experiment was resown, but the $8\frac{1}{2}$ inches of rain were inadequate to maintain the growth of the crop, which used very little of the stored water. The effect of water storage by the fallows was therefore carried into the 1954 season. The experiments are continuing; autographic recording of soil temperatures under different covers, and at different depths under bare soil, were begun in November, 1953.

Soil Structure Studies

Coffee Research Station, Ruiru

For the first six months of 1953, visits were made as often as possible to the Coffee Research Station, Ruiru, where the arrangements mentioned in the 1952 E.A.A.F.R.O. Annual Report were continued. In all more than 20 one-day visits were made during the year. Mr. J. B. D. Robinson arrived to take over their Soil Science Laboratory in May and handover arrangements were completed during June. Occasional visits were made later in the year to continue the co-operative studies, begun in 1952, of the tilth produced by a new modification of a rotary cultivator. Gypsum resistance units were also installed in an experiment carried out by the Soil Conservation Service on pineapple cultivation at Ruiru.

Reports were prepared during the year on the series of soil fertility and soil moisture conservation experiments carried out jointly with the Agricultural Officer, Mr. P. A. Jones, during the preceding five years. The first paper on these experiments was submitted for publication during the year, and will appear in the *Empire Journal of Experimental Agriculture* in January, 1954. The tilth studies on rotary cultivation were incorporated in a joint paper on tillage, completed during the year.

Soil Structure Effects of Crop Rotations in Uganda

Sixty soil cores, taken on the Uganda Department of Agriculture's rotation experiment at Kawanda, were submitted to a comprehensive series of laboratory tests during the year. Pore-space distribution was measured on tension plates and percolation rates were determined both in conditions of flooding under a constant head, and of exposure to artificial rainfall of controlled drop size. Messrs. Chenery and Mills continued at Kawanda the soil sieving tests for crumb structure both by the manual method of Martin and the mechanical

oscillation and rotation technique developed by Pereira. The results, which will shortly be submitted for publication, show that substantial changes in crumb structure can occur without any appreciable improvement in percolation rates, particularly when tested under rainfall impact. Similar results were found for a contrasting soil type in the tillage experiments at the Coffee Research Station at Ruiru, mentioned above, and it appears doubtful whether crumb-sieving measurements are sufficiently sensitive as indicators of the field behaviour of soils under tropical rainfall.

Restoration of grassland in an eroded African Land Unit

Co-operation with the Kenya Department of Agriculture in the field experiments in the Machakos area has continued, and four visits were made during the year. The tragic death of Mr. V. R. Beckley in the Mau Mau disturbances, brought to a close a valuable collaboration in this experiment. Records of herbage conditions on all of the eighty half-acre paddocks were made on two occasions, and routine calculations on carrying capacity have been maintained. The main object of the current work is the assessment of the carrying capacity for native stock of the renovated pasture under the variable rainfall conditions of this semi-arid area, and of the effects of the different grasses on soil structure and soil fertility.

Agricultural Meteorology

Evaporation measurements from the raised U.S.A. Weather Bureau pan, and from a sunken pan insulated by an air-gap from the soil, were made throughout the year, and a double walled "Trumble" tank, built in the E.A.A.F.R.O. workshops, was installed in December. Radiation estimates were made by the Gunn modification of the Bellani distillation apparatus by three Robitsch recorders, and by the Campbell-Stokes sunshine recorder. These were compared, over two months, with radiation records taken by the Plant Physiologist with a Moll Thermopile and a Cambridge Dot Recorder. Open-pan evaporation was compared with estimates computed by the method of Penman for three stations at altitudes of 5,400, 6,800 and 7,200 feet. The results are most encouraging and further studies of this nature will be made.

Visits

In February the extensive rotation experiment conducted by the Uganda Department of Agriculture at Serere was visited in company with Dr. Crowther of Rothamsted and Dr. Chenery of Kawanda. Co-operative studies on the soil structure effects of the rotations were subsequently begun a year later. The visit to Uganda was followed by 10 days in the Sudan, where a brief study of the existing soil and water data was made, with a view to promoting economy in the use of irrigation water. A paper on this subject was read to the Agricultural Research Conference at Wad Medani.

In Tanganyika a visit was paid to the Sisal Research Station at Ngomeni, where soil moisture aspects of weed control in sisal were discussed.

Soil Survey

Staff

G. H. Gethin Jones ..... *Soil Surveyor*
R. M. Scott ..... *Soil Surveyor*

Increasing experience has shown that, over very extensive areas of peneplain country in East Africa, the kinds of soil and their distribution are closely related to the state of maturity of the landscape. This is especially the case where the parent material and the soils derived from it contain stable, coarse fractions, whose presence makes for differential soil re-sortment and associated drainage. An appreciation of the stage of evolution of the soil pattern in terms of soil sequences or catenary conditions offers valuable guidance in classifying soils in a new region. It also expedites large-scale mapping.

Soil surveys have been carried out over regions agreed upon with the territorial Departments of Agriculture, where it was known that the information made available would have immediate application in problems of land usage. The category of soil classification and the kind of mapping done depend upon the extent of the regions and the immediate object of the field work. Whatever the land-use problem involved, the surveys were based on a permanent and objective classification of the soils as natural bodies, and not on the basis of soil fertility or land-use units. With a knowledge of the distribution of different kinds of soil and an estimate of their general fertility, and also by taking into account other natural resources, it was possible to estimate the land-use values of the different regions surveyed.

Soil Surveys

Kenya.—Owing to unsettled conditions, survey work involving the mapping of Soil Associations has been confined to the plains between Donyo Sabuk and the Mua Hills beyond the Athi River. On these plains there are extensive areas of grey-black and black, neutral to calcareous, tropical black earths derived from gneiss on the old peneplain, from the locally-overlying phonolites and tuffs on gentle slopes, and also from ancient lake beds. All have the common property of becoming almost impervious when wet, followed by marked shrinkage on drying, such that, with the falling in of loose surface soil into the cracks, there is a seasonal kneading of the soil and hence uniformity with depth. Except where derived from more recent alluvia, these soils carry a similar grass-*Acacia* vegetation and are characterised by the presence of numerous, almost flattened out, relic termitaria. The soil unit is a soil complex made up of the black clay which contains exchangeable sodium and dispersed areas of better drained, non-cracking, more calcareous, grey-brown clayloams on the sites of the ancient termitaria. With a characteristic vegetation, and the associated termitaria showing up well on aerial photographs, this soil can readily be mapped with a minimum amount of ground work. Off the black clays the soil pattern is very hetero-

genous, requiring much field work for classification and mapping. The main Soil Associations occurring over an area of about 150 square miles have been mapped on a scale of 1: 50,000.

In Kenya there has been continued co-operative survey work with the Departmental Soil Chemist and interested Agricultural Officers. This has taken the form of joint tours, when the basis of soil classification was discussed and the main classes of soil to be mapped decided upon. Some boundaries were marked on the tracks traversed. Such a tour of the coastal region from Malindi to Ramisi, where the geological formations are Pliocene to Recent, and where there has been a planing down by erosion, showed that the soils were closely related to the lithology of the parent material. A similar joint tour was made over portions of the Nakuru district. Soil profile samples have been taken to serve as type profiles of the classified soils.

Tanganyika.—At the request of the Agricultural Department a reconnaissance soil survey was carried out over representative portions of Usukuma and N.E. Bukoba, bordering on Lake Victoria. In the former region, the African cultivator has long had his own system of soil or land nomenclature and officers of the Usukuma Development Organisation have done a large amount of soil mapping as a guide to African settlement. This was largely based on using soil units and vernacular names already in use. The African custom of naming soils is associated with the repeated occurrence of certain soil and site conditions with a similar vegetal cover. These need particular methods of cultivation and have different agricultural uses. The different soil classes, or rather land units, cover extremes of soil texture, colour and drainage conditions and occupy particular topographical positions, such that the peasant, aided by the natural vegetation or the cropping system, is usually able to name soils from a distance. This illustrates the important role of soil sequences or catenary conditions in the classification and small-scale mapping of soils in country which has reached a late stage of peneplanation. It was noted that the same soil name often covered a fairly wide range of soil conditions; conversely different vernacular names were sometimes given to fairly similar soils in different parts of Usukuma. The soil mapping carried out by the Usukuma Development Organisation has provided initial useful information on the general distribution of different kinds of soils in undeveloped regions, and has guided the direction and scope of new African settlements. However, there is a need for a more objective approach to soil classification and also the noting of permanent features, other than soil boundaries, which bear on farming developments. A feature of Usukuma and other parts of the Tanganyika peneplain is the very extensive occurrence of heavy and often compacted 'bottom land' soils of high mineral fertility, offering scope for future mechanised farming. The 'land-use' maps prepared for the settled districts comprise a valuable historical record of the present distribution of different crops.

In N.E. Bukoba, with a different geological history and a high rainfall, the uplands have highly leached old 'mantle' soils, which were originally derived from sandstone. An interesting feature of the upland soils is that by long experience the cultivator has developed

a system of land usage suited to these impoverished sandy soils. Plant nutrients in the form of crop residues, manure and cut grass are removed from extensive areas of occasionally cropped grasslands and concentrated within the scattered village gardens, thus giving fertile lands for the growing of both cash and subsistence crops. With the increasing mineral impoverishment of the open lands it has now become essential to bring in fertility from outside sources. Future farming developments depend much upon the results of field experiments at Muruku. In the inland lowlands there are extensive areas of seasonally wettish, drab-coloured, heavy lacustrine and alluvial soils. Though unsuitable for individual cultivation by hand implements, they are amenable to regional development, which would involve flood control and land-drainage measures, and hence make possible mechanised production of special crops.

Uganda.—A soil survey was made of an area in South Busoga where large-scale sugar cane production was contemplated. It had long been depopulated by epidemics of sleeping sickness and had largely reverted to inaccessible forest and dense thicket. The Uganda Development Corporation agreed to open up the region by bull-dozing vehicle-tracks and the cutting of surveyed traverse lines. An approximate vegetation map which also indicated relative topography was prepared from available aerial photographs and used as the basis for planning the pattern of tracks and traverse lines. The latter were arranged, as far as possible, so that they cut across the likely trends of soil sequences. Including the vehicle-tracks, the base map for this survey comprised 206 miles of surveyed lines on a scale of 1: 10,000. With a very short range of visibility and the difficulty of penetrating the dense vegetation, the field work had to take the form of a detailed reconnaissance survey, which, except in more open areas, had to be confined to classifying and noting soil boundaries along the traverse lines. After working out the classes of soil present, the two surveyors worked separately along the traverse lines. The mapping of soil boundaries between the traverse lines had to depend on characteristic features shown on the aerial photographs. Where ground work had shown clearly that distinct changes in the natural vegetation coincided with soil changes, such as those brought about by differences in drainage, the soil boundaries could readily be interpolated. Other soil boundaries tended to be associated with the vegetation, but the correlation was not sufficiently trustworthy for mapping purposes. However, it was observed that particular soil sequences or catenary conditions did coincide with relative position on similar kinds of slopes, so that a stereoscopic study of the aerial photographs, and a knowledge of altitude as indicated along the traverse lines, showed the approximate alignments of such soil boundaries between neighbouring traverse lines. Other soil boundaries could not be similarly mapped, and in such cases soil classes are shown by numbers along the traverse lines only. The distribution and shape of isolated hills with rock outcrops and steep slopes could readily be mapped. The laborious task of interpreting soil boundaries from the aerial photographs and the preparation of the soil map on a scale of 1: 25,000 was done by Mr. Scott. The analyses of 121 soil samples, representing 23 type-profiles, were carried out by the Chief Chemist of the Uganda Department of Agriculture.

The Mapping of Soil Classes in Association

G. H. Gethin Jones

Soil maps are prepared on the basis of giving the maximum amount of reliable information according to the kind and detail of field work carried out and the scale of the map. In detailed surveys of experimental stations, maps have been produced on a scale of 1 : 5,000 showing the boundaries and phases of Soil Series. In Uganda, based on a detailed reconnaissance along surveyed traverse lines only, it was possible to produce an approximate soil map on a scale of 1 : 25,000 for 150 square miles of country at the level of the Soil Series, except for a part-sequence and part-complex of seasonally wettish, pale-coloured, sandy soils on slopes which had to be grouped together at about the Soil Association level. Though there are well-marked catenary conditions, such that the soil distribution could be given in a simple form, using catenary notations as convenient mapping units, much more useful information is made available in a map showing the determined boundaries of the different catenary components and hence the location and extent of the different kinds of soil.

On the other hand, following a reconnaissance tour only of representative regions over about 4,000 square miles of peneplain country in Usukuma, Tanganyika, it was only possible to obtain a general picture of the distribution of the main kinds of soil and to note—where such occurred—the nature and relative extent of the catenary associates and how they varied with different sets of geological and physiographical conditions. In this instance, without any field mapping of soil boundaries but making use of all possible sources of information, it was only possible to prepare a small-scale, high-category soil map.

The noted soil distribution presented a choice of methods for mapping. Regions with a geographical association of soils with fundamental genetic and morphological differences could not readily be mapped in terms of the dominant Great Soil Group only, as this would have suppressed the presence of other distinct kinds of soil. On the other hand, though large tracts of country showed a particular general soil sequence, the proportions of the component parts varied greatly and, with a slightly different topography or stage in peneplanation, one component or other was missing. It would have been misleading to map the whole under one Soil Catena. Thus, in the neighbourhood of Ukiriguru, in hilly country, the Soil Catena of the same name, originally suggested by G. Milne, is complete with the highly coloured, upland soil derived from granite as a dominant. South of the Magogo river and towards Ilula, in more gently undulating country, there is very little of the upland soil and a preponderance of the scantily covered, non-cracking, dark grey, gritty, sandy clay-loam to sandy clay 'hard-pan' soil extending much further up the slope. Still further to the south, the soil pattern merges into a region of about 500 square miles of low-lying, dark grey to black, fissuring clays, which are usually calcareous at depth. There are only small isolated patches of the 'hard-pan' soil and a grey sandy soil at slightly higher elevations.

A provisional method of small-scale mapping, both for areas about which little is known and for reduced-scale maps prepared from more detailed maps, is to allow for such Great Soil Groups as are definitely dominant and also for any catenary associates which are present. The main Soil Groups are indicated in colour wash — as for other regions where there are no catenary conditions — and the remaining catenary components super-imposed in the form of hatchings of the same colour as would be used for areas where such soils are dominants. Thus for the regions described above, the northern more hilly portion is mapped as ferruginous orange sands (*Ikurusi*), with colour hatchings for the remaining four catenary components, whereas for the middle zone, the base colour represents a Planosol (*Itogoro* and *Imbambasi*) with hatching for the ferruginous grey sands (*Luceni*) and the grey to black fissuring clay (*Mbuga*). The southern region of extensive 'Mbuga' with very little other kinds of soil is mapped as such without any additional hatchings. The same applies to the brownish grey to black, friable loam over secondary calcium carbonate derived from marl (*Ibushi*). This method allows for the continuity of mapping with other regions without catenary conditions and a glance at the colour indicates the general distribution of the Soil Groups. In the preparation of a soil map of East Africa on a very small scale there would have to be less differentiation in catenary mapping.

The section has co-operated with survey work done by Mr. B. Anderson of the Overseas Food Corporation at Nachingwea. He has paid special attention to the study of catenary conditions on an old land surface of peneplanated gneiss and the suitability of the classified soils for the growth of different crops. His report will be found on p. 85.

Mr. Gethin Jones was appointed the technical representative of British Colonial Governments in Africa South of the Sahara, for the first meeting of the Council of the Inter-African Pedological Service held at Yangambi, Belgian Congo.

Field discussions on the genesis and classification of tropical soils have been held with Mr. B. Anderson, Overseas Food Corporation, Tanganyika, Mr. E. M. Clegg, Soil Scientist, Northern Rhodesia, and Prof. Charles L. Sarthou and Mr. Davis of the United States Technical Co-operation Service from Ethiopia. Brief visits were also made by Dr. E. M. Crowther and Dr. A. Muir of Rothamsted, Dr. N. Simansky, F.A.O. and Prof. G. Aubert of Paris.

Statistics

STAFF

P. Robinson ..... *Statistician*

The maps of annual rainfall reliability, which were completed towards the end of last year, have aroused interest in East Africa and elsewhere. These maps show reliability, expressed as a probability, of receiving at least 20″ or 30″ during the year. Part of the 30″ map covering the Kenya Highlands was published in Mr. Troup's

report on the general economy of farming in the Highlands. Those areas that do not receive 30″ in more than 1 in 3 years on the average are confined at present to ranching. It would therefore appear that in Kenya, under tropical conditions where transpiration and evaporation are high, the success of arable farming depends on receiving at least 30″ per annum. In Tanganyika the African population is concentrated in areas of high reliability, except in those governed by the tsetse fly. A map of the reliability of seasonal total rainfall in Tanganyika, which has in general a single rainy season, showed even better correlation with population. More detailed information on certain specific areas was requested by the Department of Agriculture, Tanganyika, and by the Uganda Development Corporation, in investigations on the growing of sugar cane.

Assistance in the design of experiments and in the analysis and interpretation of results has been given to various departments and organisations in Uganda, Kenya, and Tanganyika, as well as to officers of E.A.A.F.R.O. In particular, seed-rate trials with wheat in the Kenya Highlands have been examined. The results of these experiments suggest that, contrary to normal practice in Britain, the seed-rate should be lowered on poorer land.

Much time has been given to problems arising in the programme of the Animal Industry Division. Experiments on pastures present many more problems than those on arable crops. The effect of a treatment on a pasture is important, but it is just as important to determine the eventual effect on the animal. Starting with the simpler problem of determining the effect of treatment on pasture, the optimum size and shape of plot for such experiments was investigated. Results showed that a long narrow plot gives a lower variance than one nearly square, and also suggested that the plots should be rather larger than those at present in use in East Africa. The eventual effect of the treatment on the animal is usually measured by a comparison of liveweights. It is essential therefore to determine the technique to be used in weighing before the results of experiments on animals can be reliable. The day-to-day variation after different treatments, including time of day for weighing, was therefore examined, and it is hoped that the results of this investigation will be published next year.

Two safaris were made during the year in connection with problems similar to those considered above. The first was to the Grassland Research Station at Kitale. Experiments on ley establishment, rotations using grass to maintain soil fertility, and other problems were discussed. The effect of treatments and grazing animals on pasture composition is important, and several methods of determining pasture composition have been suggested by various workers. Two types of apparatus based on that originally designed by Levy in New Zealand were used on pasture at Kitale. Interesting results were obtained and are at present being followed up by work on other types of pasture.

The Veterinary Research Station at Mpwapwa in Tanganyika was also visited. Problems more directly concerned with animal experimentation were discussed, and also certain points concerning pasture

investigation. Assistance in statistical work was given and part of the time was devoted to teaching statistical methods to some of the African computing staff.

Until recently our help has been mostly required for agricultural experiments; and it is encouraging to record that statistical methods are now being applied to research on animals in East Africa.

Joint Division of Animal Industry

STAFF

M. H. French ..... *Head of Division*
D. W. Duthie ..... *Biochemist*
A. Rogerson ..... *Nutrition Chemist*
H. P. Ledger ..... *Farm Manager*
I. B. Pereira ..... *Scientific Assistant*

The building programme has been completed and the Metabolism Laboratory, for studying digestibilities and feeding values, is in use. Dr. A. Rogerson, the nutrition chemist provided by E.A.V.R.O., joined the Division in March and, in addition to fitting up his laboratory and in spite of deaths in his trained sheep from Nairobi Sheep disease, has carried through twenty-five digestibility trials on local hays, silages and supplementary foodstuffs. It is hoped that this work will be extended to studies of the feeding values of grassland herbage during the coming year. Plots have been laid down for this purpose; but whether they will be in a suitable condition for investigation depends on how well they survive the severe drought during their establishment and on the weather during the early part of their second year's growth.

These proposed studies on the feeding values of grassland herbage, by determining the digestibilities of cut herbage in laboratory metabolism crates, will form part of a wider investigation into the technique of measuring pasture productivity. The latter seek to evaluate the relative merits of and the correlations between estimates of the yield and chemical composition, the feeding values as determined by digestibility trials, conducted in the laboratory and on grazing animals, and measures of liveweight increase from grazing trials. During the year uniformity trials have been started to determine the minimum size, the shape and the number of plots required to estimate the yield of grassland herbage. Drought interfered with this work, and preliminary observations only were made on sown oats and naturally regenerated pasture. This work will be extended to cover vegetatively propagated star-grass and Kikuyu-grass pastures and possibly a seeded grass.

As a preliminary to the grazing trials, Mr. Ledger, with the statistical help of Mr. Robinson, is conducting a series of experiments with cattle and sheep to determine the errors in measuring liveweight at different times of the day and after varying intervals of with-

holding food, water or both. The study will be extended to include the effects of walking varying distances from the experimental paddocks to the weighbridge, the number of animals required for a grazing trial, estimates of the accuracy of liveweight increases or losses, the optimum size of the stock to be used and the need for a 'conditioning' period prior to the experimental grazing.

Mr. Ledger has made practical observations on the making of hay from oats and grass and, in addition to developing the farm, which has now been limited to 400 acres, he has co-operated in the sheep, pig and poultry investigations. These latter investigations, although primarily designed for studies on the efficiencies with which foodstuffs are utilised by animals and birds, are also providing material for study by the Geneticist and Physiologist when these officers are appointed.

The Division is co-operating with the Pasture Chemist of the Kenya Agricultural Department in a factorial fertiliser trial on star grass. In conformity with a programme previously arranged with the respective territorial Directors, the Head of the Division has spent 75 days away from Muguga visiting territorial investigation centres concerned with livestock breeding and improvement. The Division was visited by 92 Government officials, 64 settlers, 109 students and 20 overseas visitors.

Animal Nutrition

A. Rogerson

Twenty-five trials have been carried out on pairs of sheep to determine the digestibility of locally-grown foodstuffs. Oat silage made in a pit has been intensively investigated: five trials on this silage have been conducted by varying the ratio of silage to hay in the ration, in order to determine the effects of such variations on the calculated digestibility of the various nutrient components. Only too often determinations of the digestbility and the feeding value of a given fodder in a mixed ration have been carried out by investigators who have chosen an arbitrary ratio between the ration components and assumed that the results obtained for this particular mixture will apply for any other combination of the same constituents. The above series of trials with oat silage were undertaken to determine the errors that are likely to be encountered under East African conditions, and to enable the optimum ratio for these two types of foodstuffs to be ascertained and used in future studies. Other silages investigated during the year were sunflower, maize and lupin, buckwheat and an overheated oat silage made in a tower. These four silages were fed with hay only at the lowest, and probably the most commonly used, of the above ratios. Digestibility studies have also been conducted on an oat hay allowed to dry in the swathe in the normal manner and on another oat hay made on racks in the field. Studies have also been conducted on the feeding values of rack-dried grass hay.

Trials were carried out to investigate the variations in the digestibility of native and exotic sheep, but no differences were found

to occur. It has been noted, however, that native sheep are less fastidious feeders than Merino types; and the former would seem preferable for studies with relatively unpalatable foods.

In another set of trials, the effects have been studied of adding protein, urea, starch and sugar to a fairly typical local hay. Data have been collected on the effects of such additions, individually and in combination, on the digestibility of the various feed fractions and on the urinary nitrogen exretion. In view of the highly fibrous nature of local fodders, it would seem very desirable to discover whether such additions have an advantageous influence on fibre digestibility and, because of this, on the feeding value of local fodders.

A preliminary study has also been made of the toxicity of the alkaloid found in the seeds of the commonly-grown giant bluish-white lupin. Various methods of extraction have been tried and, whilst alcohol has been found to be the most efficient solvent, the complexity of the extract makes purification a difficult procedure. Although intra-peritoneal injection of the isolated alkaloid into guinea pigs has caused rapid deaths, it seems fairly safe to say that, in practice, no farm animal would be likely to consume a sufficient quantity of lupin seed of the type investigated to cause death. Rabbits of approximately one kilo liveweight, consuming the equivalent of 50 milligrams of alkaloid daily in the form of crushed lupin seed, seemed entirely unaffected after a period of five weeks. The alkaloid content of other types of lupins merits investigation, and further studies are projected with both seeds and whole plants. In this connection, it is interesting to record that silage made from a maize-lupin mixture proved highly palatable and had no deleterious effects on the animals or their digestive systems.

Techniques for Measuring Grassland Productivity

M. H. French, H. P. Ledger, P. Robinson and A. Rogerson

Since herbage must continue to be the basic food for the larger domestic animals, considerable investigational work is being undertaken by territorial Departments on the selection of better herbage species and the improvement of existing ones. This work also includes studies of establishment and management practices to increase the yield and extend the period of growth. Ultimately, the relative merits of the improved pasture species must be judged in terms of livestock productivity; and this Division is investigating techniques for measuring grassland productivity and their applicability to East African pastures and conditions. This apparently easy problem is full of difficulties and the aim is to offer, to territorial Departments, techniques which will allow more accurate measurements to be made and permit a closer correlation between the results from the different territorial centres.

Uniformity trials have been carried out on 432 plots of naturally regenerated mixed grasses and on 288 plots of sown oats, in an attempt to obtain data on the number, size and shape of grass plots required to give a reasonable estimate, of known variance, of the yield and

composition of the herbage in a field. This work will be extended to include studies with seeded and vegetatively-propagated grasses; but already the preliminary results emphasise the need for long narrow plots rather than broad ones, if the coefficients of variation in fresh- and dry-weight yields are to be kept low.

Paddocks have been planted for uniformity trials with grazing animals; and it is hoped to collect data on the minimum size of paddocks, the number of grazing animals and the degree of replication necessary for reliable results. Time has been spent in obtaining uniform grass covers, so that the accuracy of the early observations may be increased. This study will include observations on the rate of defoliation and the extent to which electric fences and strip grazing affect the results.

Other paddocks have been planted with various grass species. These will be employed for studies that aim at correlating productivity estimates based on yields of dry matter and its crude constituents with the corresponding estimates from digestibility trials, using either cut herbage in laboratory crates or 'bagged' grazing animals. It is then hoped to correlate these three estimates with others based on liveweight changes in grazing animals. Attempts to evaluate pasture productivity by means of milk yields will be deferred until data have been accumulated on liveweight gains. The recording and interpretation of liveweight gains has, in the meantime, been the subject of study, so that, when the prepared paddocks reach a suitable state for grazing and cutting, the full programme above can be put into operation.

Techniques for Recording Liveweight

H. P. Ledger and P. Robinson

During the latter half of the year, a series of weighing trials were commenced to study and evaluate the errors that are likely to be encountered in experiments where liveweight changes are used as the measure of productivity. It is hoped to publish, during the coming year, the results of examining the following different techniques:—

(a) The variance in day-to-day weight records of different types of animals weighed at specified times and under similar conditions each day by different recorders.

(b) The variance in day-to-day weight records of two-tooth, four-tooth and mature steers, under normal daytime grazing but penned in an open yard, adjacent to the weighbridge but without access to food, during the night, and when:—

(i) allowed water at 6 p.m. but not again until after being weighed the following morning;

(ii) allowed water at 6 p.m. but not again until just before being weighed the following morning. (It is interesting to note that the cattle usually refused the morning water.)

(iii) allowed water *ad lib.* during the night and weighed the following morning;

(iv) after the morning weighing, the cattle were walked ½ mile and then re-weighed;

(v) the animals were weighed at 6 p.m., immediately after returning from their daytime grazing, but before their evening watering;

(vi) the animals were weighed at 6 p.m., immediately after returning from their daytime grazing, and were then re-weighed after being allowed to satisfy their thirst.

From these studies it is hoped to answer such questions as:— what is the minimum number of animals or the minimum number of weighings on one or more consecutive days to give reliable liveweight estimates, what time of day gives the least errors in liveweight estimates, and do these conditions apply equally to immature and mature stock? For grazing trials, the results will apply only when the common East African practice is followed, i.e., confining the animals without food in an open yard at night. Further studies will be needed to determine the comparable data where night-paddocking is practised or where the animals have access to food during the night

In addition to the foregoing studies, an investigation has started to determine the effects of different nutritional planes (above, at and below maintenance requirements) on the subsequent liveweight changes when all the animals are given the same experimental diet.

Techniques for Feeding Trials

M. H. French and H. P. Ledger

Experiments are being conducted to study the various factors affecting the accuracy of feeding trials generally, and to define more precisely the conditions that should be observed under East African conditions and when using slow-maturing indigenous or rapidly-maturing exotic stock and crosses between the two. In general, feeding trials fall into two main categories, i.e., group feeding and individual feeding; and, although certain trials, such as grazing experiments, must be of the group type, others, such as feed-lot trials with cattle or fattening experiments with pigs, can be performed with either technique.

In designing group-feeding trials, investigators take considerable trouble to equalise the group means for age, sex, weight, breed, parentage, previous history, etc.; yet the variance within groups is often greater than between treatments and inconclusive results are obtained. For cattle, this Division is working with both Zebu and grade European animals and attempting to define the conditions and factors which will reduce the variance between animals. If this effort is successful, it will provide the means whereby results from different

territorial stations will be more readily comparable and mutually complementary. Attention is now being directed to the influence of such factors as liveweight, age, weight/age ratio, physiological age and the previous nutritional plane on experimental liveweight changes. The need for and the details of preliminary 'conditioning' periods are being studied, particularly in relation to grazing trials and to the possibility of using sheep instead of cattle in such trials, in order to reduce the acreages necessary on experimental stations.

Direct comparisons of the group- and the individual-feeding techniques are being made with poultry, whilst the individual-feeding procedure is under more detailed examination in pig-feeding trials. The smaller size and initial cost of poultry, their smaller food consumption, the cheaper equipment and labour charges and their more rapid growth are some of the reasons for choosing them for preliminary trials in preference to the more costly and more expensively maintained cattle. Although it is too early to comment on the data, valuable information has accumulated on the day-to-day problems of conducting such trials, and on the points where it is unwise to economise on staff or facilities. The preliminary data suggest that, apart from the main objective, useful statistics will be obtained on the relative economics of table-bird, egg and bacon productions, for all of which there must inevitably be some competition between man and his livestock for certain foodstuffs.

Hay Making

H. P. Ledger

The ideal hay-making weather this year confirmed previous experience that oats can be a difficult crop to cure sufficiently for baling without the risk of reducing its feeding value considerably. This difficulty is due partly to the greater moisture retention in the stem nodal areas; when this moisture is subsequently released by stem breakages during baling, it encourages heating and mould development. Partially dried oat fodder also absorbs more moisture from night dews than partially cured grass hay. These two factors extend the period during which cut oats must be exposed for drying in the field, in the more usually employed methods of hay making, with the corresponding increase in handling and turning and the consequently greater risk of bleaching and loss of leaf.

The difficulty has been successfully overcome by a modification of the Scandinavian system of rack drying, the details of which will shortly be published.

Sheep

M. H. French and H. P. Ledger

It is not intended to start experiments with sheep until there are available sufficient animals of known history and bred on the farm. Three small flocks of Masai, Black-headed Persian and Dorset

Horns have been established for this purpose, in order that animals will be ready for genetical and physiological studies on mutton production. Although the experimental records will include observations on the quality and yields of wool, the main objective will be meat, and to this extent will supplement the studies being made on cattle in territorial stations. The more rapid rates of reproduction and maturation will allow a greater range of studies to be made, in a shorter time, on the genetic and physiological possibilities of fixing a new, locally-adapted breed from the interbreeding of crossbreds.

Meanwhile, liveweight and temperature records have been kept throughout the year and are to be studied for differences between indigenous and exotic breeds and for any information on the acclimatisation of the latter.

Pigs

M. H. French and H. P. Ledger

A small pig unit has been established from animals bred by the Tanganyika Veterinary Department. These animals were chosen because experiments were made on the same herd in the 1930's by one of the authors (M.H.F.). In connection with the general study of livestock adaptability, it was considered instructive to compare the efficiency of food conversion and rates of growth in a given herd of pigs after an interval of 20 years in East Africa. Admittedly, the strain has been 'refreshed' by importations at intervals during this period, but the imported animals have originated from the same pedigree herd in the United Kingdom. From feeding trials conducted on the first three litters born at Muguga, there is no indication that the rate of growth or the economy of food utilisation have deteriorated. The latter is appreciably superior to the average rate of conversion of food into liveweight increase in Great Britain.

In addition to providing data on the individual feeding technique, the pig unit will be used for a genetic study on the possibility of breeding for better food utilisation whilst retaining good carcase quality. All the Muguga feeding trials are followed by an assessment of carcase quality. Hence, practical information relating to local food mixtures is accumulating, to supplement comparable data from territorial stations in different environments.

Poultry Production

M. H. French and I. B. Pereira

This work was started in 1952 by Mrs. M. A. Ledger. In the small poultry unit, the five breeds have been trapnested and the egg numbers and weights have been recorded against food consumption. The number of low producers in commercial flocks varies considerably, but, since their presence is often unknown, they can be a decisive factor in profitability. Although few poultry keepers could

afford to trap-nest continuously, many would be prepared to do so for limited periods in order to cull the poor layers. For this reason, the egg records are being analysed statistically for correlations between total yields and estimates based on early productivity or on short-period tests. Included in the study of economical egg production are the effects of seasonal variations in yields, how these are affected by the age at which and the month in which birds start laying and the point to which yields may decline, with age, before lifetime profits are affected.

Pedigree hatching is carried out and breeding cockerels are being assessed and selected on their daughters' records. Records of growth rates to sexual maturity are being kept as well as data on hatchability, viability of their chicks and mortality rates in their progeny. The pullets reared from the imported birds have given the yields shown in Table I in their first year of laying.

TABLE I

EGG YIELDS OF PULLETS REARED FROM IMPORTED BIRDS

Breed	Flock average number of eggs	Flock average egg weight	Maximum number of eggs	Minimum number of eggs
North Holland Blue	141.1	53.6 gm.	214	34
Brown Leghorn	141.5	54.5 „	170	99
Welsummer	138.8	61.0 „	181	53
Legbar	145.5	54.8 „	209	38
Cambar	176.5	54.3 „	237	94

With the exception of the Cambars and Welsummers, these first-year results were below expectations both in yield and egg size. The first generation of pullets hatched on the farm are now being recorded and, although it is too early to draw conclusions, the locally-hatched pullets have out-yielded their imported dams at comparable ages. These five breeds were chosen because it was considered that each offered greater scope for genetic improvement and better opportunity for assessing the merits of breeding methods than any of the more productive breeds, and the above figures support this assumption.

Weekly growth rates are measured for all birds hatched and data are accumulating on the food consumption per lb. of liveweight increase at all ages until sexual maturity. This study has exposed many of the inherent difficulties in work of this nature and the imperative need for adequate facilities. It is also providing data on how normal efficiency of food utilisation can be upset by any factors which interfere with the normal rate of development.

Comparable data are accumulating on table-bird meat production with Aylesbury ducks and Roman Geese. With the former, there is a clear-cut drop in efficiency of food utilisation after the 10th week,

suggesting that management should aim at the sale of ducklings weighing 4¼-5 lb. at this age. Whilst geese are traditionally graziers, they can be reared intensively, when the aim should be to sell at 3 months old weighing 8-9 lb. After this age, the efficiency of food conversion into liveweight drops sharply.

Deep Litter System

M. H. French, H. P. Ledger and I. B. Pereira

In view of the popular interest in the 'deep-litter' system of poultry management and because of controversy regarding its applicability to East African conditions, a trial has been conducted using three breeds of fowls under the following three systems: (a) deep-litter, (b) open runs and (c) open runs with deep-litter houses. First-year pullets were allocated at random to the pens just before they began laying, and the trial ran for a year. Under the dry conditions of 1953, there was no significant difference in egg yields or in food consumption between the three system of management although there was a significant difference between the egg yields of the different breeds. It will be interesting to compare the systems during a wet year.

Experimental Farm

H. P. Ledger

General

No new land has been cleared of bush during 1953. The main labour force has been engaged on the further development of the land already cleared and on the establishment of experimental plots. This year's low rainfall greatly assisted in clearing of land of couch grass and perennial regrowth, but it had the reverse effect on the establishment of the experimental plots. Some 25 acres of star grass, local name "Igoka" (*Cynodon dactylon*), 10 acres of Kikuyu grass (*Pennisetum clandestinum*) and one acre of a fine type of *Cynodon*, suitable for sheep grazing, have been established by vegetative propagation.

Attempts to establish, from seed, plots of *Phalaria tuberosa*, *Chloris gayana*, *Melinis minutiflora* and lucerne, sown in mixtures with one or other of these grasses, failed and will have to be repeated next year.

It had been hoped to establish all the grass plots during the long rains in April so that the technique studies could have been begun by the beginning of the short rains in November. Grass coverage during the year was so slow, however, that it was possible only to obtain yield records from uniformity trials laid out on naturally regenerated pasture, from a 1952 clearing, and on a 1953 crop of oats. Two cuts were made from the factorial fertiliser trial on star-grass establishment being run in conjunction with the Pasture Chemist of the Kenya Agricultural Department.

Buildings

A list of permanent buildings completed in 1953 is given on p. 5. In addition, nine experimental silos were constructed and temporary buildings erected to house the individual-feeding pens for pigs and cattle; an extra deep-litter house and a poultry house for brooders and young stock were also built.

Cattle

Thanks are again offered to the Director of Veterinary Services, Kenya, for the continued loan of immune grazing stock for cleaning the farm of ticks. This is an essential preliminary to any large-scale cattle experiment.

These animals have, moreover, been used for the initial liveweight studies and the pre-experimental conditioning investigations mentioned earlier.

Poultry

The five breeds, imported during 1952, have completed their first year's laying trials and their progeny are now under test. No fresh importations have been made. Apart from occasional outbreaks of coccidiosis amongst young stock, the general health was good.

Pigs

The Large White Gilts, purchased from the Tanganyika Veterinary Department at the end of 1952, farrowed and their progeny have been used for individual feeding investigations.

Sheep

Two pedigree Dorset Horn ewes and an unrelated ram were imported from the U.K. at the beginning of the year. The ewes were in lamb but unfortunately aborted soon after arrival. One has since produced twin lambs sired by the imported ram. In addition to the flock of Masai sheep, pure-bred Persian Blackheads were also purchased for crossing with Dorset Horns. Unfortunately, several deaths from Nairobi Sheep disease have occurred.

Grass and Fodder Crop Reference Plots

The work of establishing different types of grass and fodder crops in small plots continued throughout the year. There are now some 209 species and varieties under observation. The more interesting additions during the past year included fodder beets, edible sweet lupins and dry-area lucernes.

Notes on Crops, 1952

Lampton oats grown for hay did reasonably well under the very dry conditions and yielded nearly a ton of dried hay per acre; whereas in the crop left for seed, the grains failed to fill and no seed was harvested. "Research" Barley proved sufficiently drought resistant to yield 12 cwt. (7½ bags) per acre on poor soil. Kale has again proved

to be the most drought-resistant and highest yielding green fodder crop yet tried. There appears to be scope for selecting a rapidly-maturing, drought-resistant strain of thousand-headed-kale. The more promising plants have been vegetatively propagated. "Hunter's River" lucerne, sown at 15 lb. per acre, has been established; but there has been insufficient growth to provide a cutting owing to the drought conditions.

ATTACHED C.D. & W. SCHEMES

Termite Research

STAFF

W. V. Harris ..... *Officer-in-Charge* (London)
W. A. Sands ..... *Research Officer*
W. Wilkinson ..... *Research Officer*
R. M. C. Williams ..... *Research Officer*

Mr. Sands was stationed at Muguga throughout the year. Messrs. Wilkinson and Williams were appointed in June, after holding Colonial Office Studentships for a year and working at the British Museum (Nat. Hist.) with the Officer-in-Charge, Termite Research Unit. Mr. Wilkinson arrived at Muguga in June. Mr. Williams continued to work at the Museum until his departure for Kenya in December.

Biology

The feeding habits of the higher termites continue to be studied by Mr. Sands. Experiments on feeding preferences have been carried out with *Odontotermes* and *Microcerotermes*. The role of fungus comb in the diet of *Odontotermes* would appear mainly to be the provision of a "survival factor". The location of this factor in the spherical spore-bearing bodies of the fungus is indicated by its almost complete absence in comb from which these bodies have been removed by hand before feeding it to termites. In the case of *Microcerotermes*, which does not produce fungus comb, preliminary experiments have shown that life cannot be maintained on cellulose alone. When efforts were made to measure the carbon-dioxide production of groups of 1,000 *Odontotermes* workers, the quantity produced was too small to be measurable by standard analytical methods. This suggests that the comb is not required to function as an absorbent of surplus CO_2 inside the nest.

Observations on colony foundation by pairs of alates continue. It is proving difficult to produce in the laboratory conditions conducive to the successful development of young colonies by subterranean termites. Laboratory colonies of dry-wood termites are established and provide useful material for systematic studies of the alates.

Systematics

A paper by Mr. Wilkinson describing three new species of Kalotermitidae from East Africa has been accepted for publication.

Field Work

During the first half of the year, Mr. Sands made three excursions into the Northern Frontier District of Kenya. This continues his observations on the termites of the drier parts of East Africa, which began with a visit to Karamoja in 1952.

In the second half of the year the two officers made a ten weeks' journey by road to cover a large part of Nyasaland, and also some parts of south-western Tanganyika. A preliminary estimate of the number of species found in Nyasaland is one hundred. Prior to this, little was known of the termites of this country. Detailed ecological observations were made.

Economic Problems

The identification of specimens submitted by local Departments has been continued.

Two "graveyard" trials of the resistance of local timbers to termite attack were set up at Muguga; but one of these had already been destroyed by the local inhabitants before the end of the year.

The occurrence of the dry-wood termite in buildings at the Coast, referred to in the report for 1952, has become more widely recognised, and it is hoped to make a survey of the situation.

Acknowledgments

The continued co-operation by members of E.A.A.F.R.O. and many Departmental officers is acknowledged with appreciation. We are indebted to the Director of Agriculture, Nyasaland and members of his department for valuable assistance.

Ecological Training Scheme

STAFF

C. G. Trapnell ..... *Officer-in-Charge*
I. Langdale Brown ..... *Research Student*
E. C. Trump ..... *Research Student*
N. R. Brockington ... *Probationer, Northern Rhodesia*
C. F. Hemming ..... *Desert Locust Survey*
W. D. Clayton ..... *Research Student*

The general aim of courses under the scheme is to cover during the training year three aspects of ecological survey—large-scale vegetation reconnaissance in relation to climate, combined vegetation-

soil survey, and, finally, applied ecological survey, in which field investigation involving the preceding aspects is combined with a study of existing and potential land use. The programme is a large one for the time available; and the precise application of this general approach, together with the location of individual surveys, has to be worked out according to circumstances and to the needs of those concerned.

At the beginning of the year two Research Students, Messrs. I. Langdale Brown and E. C. Trump, were attached to the Scheme, together with Mr. N. R. Brockington, Colonial Agricultural Probationer for the post of Ecologist in Northern Rhodesia. These three completed their training at the end of September. Mr. Langdale Brown has since been appointed Ecologist with the Agricultural Department, Uganda, and Mr. Trump, Ecologist with the Tsetse Survey and Control Unit of the Kenya Veterinary Department. Mr. Brockington has proceeded to his appointment in Northern Rhodesia. Mr. C. F. Hemming, of the Desert Locust Survey, arrived at the beginning of the new training year in October, and Mr. W. D. Clayton shortly afterwards in November.

Surveys and field investigations in the course of the year have ranged between west Uganda, south Kenya and the Northern Province of Nyasaland. Of these surveys, the field work for the first, a reconnaissance vegetation survey of the West Uganda Rail Extension zone, had already been done in November-December 1952. Air-cover interpretation for this survey, which involved the handling of approaching a thousand potographs, was carried out in the early part of the year in combination with other studies. The greater part of the interpretational and mapping work for this area was done by Mr. Langdale Brown, who produced a map of the distribution of eleven principal vegetation types covering an area of 5,000 square miles. This map made possible a more precise delimination than hitherto of the so-called dry zone of this region, i.e., that with recorded normals of 36 ins. of rain and under. It also provided outlines of the distribution through Ankole District of *Acacia hebecladoides*-types vegetation, which form the habitat of tsetse fly here. There is evidence to suggest that this class of vegetation may have extended into certain derelict grazing areas following their occupation by *Cymbopogon afronardus* and *Acacia seyal* var. *multijuga*, as noted in the last report, with a consequent development of areas suitable for fly.

While work on this survey was in progress, Mr. Brockington carried out a grassland-types survey of the Management Experiment Plots at the Grassland Research Station at Kitale in co-operation with Mr. Bogdan, and then participated with Mr. Robinson in a study of the estimation of ground cover by the point-quadrat method.

During March and April soil reconnaissance studies in relation to vegetation were made in the Machakos and Makueni areas. Messrs. Trump and Langdale Brown put in a period at the Makueni Resettlement Scheme, in the course of which they made an outline soil survey of the present settlement area. Analyses of type profiles from here were subsequently made by the Soil Chemistry Section. Mr. Trump's report on the results of this investigation brings out the

marked differences in fertility and potentialities of land in the settlement area.

In May, at the request of the Nyasaland Government, the party travelled south to carry out a combined ecological and land-use survey of the Mzimba and south Rumpi districts of the Northern Province of Nyasaland. Bases were kindly provided by the Administration at Mzimba and Rumpi and by the Colonial Development Corporation on their Vipya Tung Estates at Mzuzu. Vegetation- and soil-traverses were carried out over all available routes through the area; and its principal climatic zones, soils and vegetation types were determined. The sharp climatic gradients of this area were of particular interest. Profile studies of the soils of the higher and moister parts revealed a remarkable type of combined crumb and "pellet" structure, which has been traced in other highland areas in adjoining territories and may affect soil classification in this region.

In combination with the party's traverse work in the Mzimba area, Mr. Brockington conducted detailed enquiries into traditional African agricultural practice, which resulted in the determination of three main agricultural systems with minor local variants. Traditional practice is now very largely overlaid by ridge cultivation methods introduced by the Agricultural Department for the control of soil erosion. The effects of these modifications were studied, together with the problem raised by the long-handled acute-angled hoe, which is still retained and limits depth of cultivation. The problems of this area are influenced by the low fertility and crusting tendencies of the extensive Plateau soils, which deteriorate under repeated cultivation and show a poor subsequent grass cover. Particular consideration was given to the question of a policy of eradication of *Brachystegia*, intended to facilitate grass establishment on these soils and associated Red Earth belts; and for this purpose visits were paid to the Agricultural Department's eradication experiments at Zombwe and Mbawa. The Zombwe experiments on a badly damaged Red Earth provided interesting evidence of a marked improvement of soil structure and grass growth following the cutting and laying of *Brachystegia* branches, due evidently to stimulated activity of wood-consuming termites. The effect, which was checked by water infiltration determinations, was so striking as to suggest the possibility of employing cut coppice on the red soils as a means to recovery of damaged areas. This effect, however, was not found on the lighter coloured Plateau soil at Mbawa, which showed differences in termite activity. Observations on these questions were discussed with the Director of Agriculture and the Chief Agricultural Research Officer in the course of a visit to the Agricultural Research Station at Lilongwe. A report on the ecology, agricultural systems and land-use problems in the area was also drafted by Mr. Brockington after return to Muguga, and will be submitted when further field data have been incorporated.

From Nyasaland a rapid tour was made through Northern Rhodesia with Mr. Brockington. This included visits to the Agricultural Headquarters at Lusaka, to the Forestry Department's burning experiments at Ndola and to burning experiments at Lunzuwa Agricultural Station near Abercorn. At Abercorn arrangements were

made with the International Red Locust Control Service for a short period of field work in 1954.

Following this, in August-September, Mr. Langdale Brown proceeded on tour via Entebbe in order to join the Oxford University Expedition to Uganda, working in the West Nile area. He participated in detailed agricultural and land-use studies among the Alur and returned to Muguga to write up results. Mr. Brockington, meanwhile, was engaged on Nyasaland and Northern Rhodesian data. Mr. Trump proceeded to Makueni on a short field reconnaissance for the Kenya Tsetse Survey and Control Unit and was subsequently engaged on air-photo interpretation and mapping work for this Unit. All three sailed for England at the end of September.

On Mr. Hemming's arrival in October, a vegetation reconnaissance to determine the climatic zones of the Machakos area was begun at the request of the Agricultural Officer, Machakos. The vegetation of certain parts of this area is markedly influenced by soil type, and in order to prepare the ground for a climatic study certain major soil types required mapping. Two of these, black clays of the Kapiti Plains type and the Kiteta soils (of Milne's Plateau group), are effectively determinable on air photographs. With Mr. Clayton's arrival in November, air-photo interpretation was begun, and a ground check was carried out from Machakos in December. Some 700 square miles had been mapped for those soils by the end of the year, and the field work will be resumed in the new year.

REPORTS BY O.F.C. OFFICERS

During the year Mr. R. A. Wood resigned, but the soil moisture studies at Kongwa will be carried on by Dr. Pereira of E.A.A.F.R.O. The staff at Nachingwea has been strengthened by the transfer of Mr. J. S. Hemingway from Kongwa.

Rosette disease of Groundnuts

A. C. Evans

The two lines of research mentioned in the Annual Report for 1952 have been followed up, namely, the use of the systematic insecticide Schradan as a seed dressing and the field resistance shown by the variety Mwitunde.

Three plots, each two-thirds of an acre, were planted with seed treated with pure Schradan and with a proprietary commercial preparation of the insecticide, and with untreated seed. The dosage used was equivalent to half a pint of the active material per acre. A severe invasion of infective winged aphids occurred immediately after germination. The course of the infestation is shown in Table I.

TABLE I

CONTROL OF INFESTATION

	Days after emergence of groundnuts	Aphid counts, per 50 plants		
		Winged adults	Wingless adults	Nymphs
Control	9	30	34	271
	15	4	42	326
	22	0	7	30
	30	20	51	643
Schradan 'pure'	9	1	0	0
	15	0	0	0
	22	0	0	0
	30	22	0	140
Schradan 'proprietary'	9	1	0	0
	15	0	0	0
	22	0	0	0
	30	14	0	29

The control of the infestation on the treated plots was most striking and lasted for three weeks. The presence of numbers of winged adults and nymphs on the treated plots on 30th day showed that the plants were no longer sufficiently toxic to suppress a new invasion that had come from surrounding untreated areas. The results are sufficiently promising to warrant large-scale field trials.

The early incidence of rosette was equally strikingly reduced (Table II).

TABLE II

INCIDENCE OF ROSETTE

Days after emergence	Rosetted plants, 000/acre		
	Control	Schradan 'pure'	Schradan 'proprietary'
16	7.0	2.3	0.9
22	12.9	4.1	2.3
30	18.2	5.1	2.4
38	23.5	8.9	7.6

Three areas, each about 40 acres planted with the variety Mwitunde, were studied to compare its field resistance with that of the Corporation's standard variety, Natal Common. Weekly counts of aphids were made. On two fields adjacent panels of the varieties were studied, and the peak infestation on the Mwitunde was one-quarter and two-thirds that on the Natal Common. On the other field widely separated panels were studied, and the aphid population on Mwitunde was rather more than twice that on Natal Common. In all cases the incidence of rosette disease by the middle of March on Mwitunde was less than half that on Natal Common. On one field the incidence of rosette disease was estimated panel by panel. The incidence on Natal Common was fairly uniform, varying between 14,000 and 16,000 diseased plants per acre. Mwitunde panels adjacent to Natal Common had 8,000 diseased plants per acre and those most distant only 1,000-2,000 per acre. The decrease in incidence of the disease fell regularly as the distance increased from the Natal Common. In one case, where a severe infestation occurred soon after emergence, the Natal Common was ploughed in three weeks after emergence whereas the Mwitunde gave a harvestable crop (Table III).

TABLE III

YIELDS OF MWITUNDE AND NATAL COMMON PLANTED IN SAME FIELDS

LB. PODS/ACRE

Natal Common	Mwitunde	Rosette
0	710	Very severe
540	960	Severe
650	1040	Medium

There can be no doubt that there is now justification for eliminating Natal Common from the Nachingwea area and replacing it with Mwitunde. This has been done; and the prospect of securing economic control of rosette in an average season is promising. Mwitunde offers a further advantage over Natal Common in that its seed does not germinate at harvest time. Thus volunteers, which normally carry the virus and vector through the dry season, can be eliminated at low cost.

Some progress has been made in elucidating the mechanism of the apparent resistance. Tests showed that, when infested with infective aphids, Mwitunde was infected to the same extent as other varieties. Thus it appears that its superiority is due to some difference in the behaviour of the vector on it. In four experiments the rate of reproduction of aphids was found to be appreciably less on Mwitunde than on Natal Common (Table IV).

TABLE IV

REPRODUCTION RATES OF APHIDS

	Mwitunde	Natal Common	Significance
Exp. 1, after 5 days			
No. of offspring	15.5	41.6	$P = .01$
No. of adults	1.2	4.5	$P < .01$
Exp. 2, after 11 days			
No. of offspring	2.2	24.4	$P < .01$
No. of adults	0.4	1.6	$P = .05$
Exp. 3, after 7 days			
No. of offspring	78.6	237.6	$P = .01$
No. of adults	8.4	16.3	Not significant
Exp. 4, after 7 days			
No. of offspring	11.2	39.6	$P < .01$
No. of adults	0.6	3.9	$P = .01$
No. of alate forms	0.9	4.6	$P = .02$

The rate of increase of aphids is approximately three times greater on Natal Common than on Mwitunde, for both adults and total offspring. Although Mwitunde is not a very favourable host for *Aphis craccivora*, this practical advantage does not seem to be offset by a greater production of winged forms, which would tend to spread infection far and wide in the crop.

Lower proportions of aphids reared on Mwitunde are infective than is the case for Natal Common:—

Percentages of Infective Aphids

Natal Common	Mwitunde	Significance
31	0	$P = .01$
6	0	$P = .05$
51	33	$P = .01$
35	13	$P < .01$

In the last experiment, highly significant differences were found between the percentages of infective aphids from plants of each variety. A third factor of agricultural value is under consideration, namely, tolerance to the virus. A yield of 710 lb. of pods per acre under a very severe attack of rosette, and in another case 660 lb. per acre on a small plot of about three quarters of an acre, suggests that a low rate of reproduction and a low percentage infectivity are not the only factors concerned in resistance.

Since the variety Mwitunde is very mixed, there would appear to be reasonable hopes of selecting a strain that is high-yielding, unfavourable for aphid reproduction, giving a low percentage of infective aphids and perhaps tolerant to the usually severe effect of the virus on yield.

Plant Pathology Studies

J. S. Hemingway

Three main lines of research were pursued throughout the year, all on groundnuts. They were the seed-dressing trials, which were brought to completion, continued studies of the *Cercospora* leaf-spots, and observations on the incidence of "wilt" disease. Identifications and observations were made on several diseases of other crops, including *Puccinia polysora* rust of maize.

Numerous seed-dressing materials have been tested in previous years, and from that range two were selected as being the most effective. These two, an organo-mercurial and a thiram preparation, were compared in two experiments, at the respective rates of 4 ozs. per cwt. and 2 ozs. per cwt. The results confirmed previous indications that the two materials gave similar improvement of emergent populations over the untreated controls, while the thiram dressing also controlled "crown rot". ("Crown rot" is a seedling disease caused by *Aspergillus niger*, which can cause post-emergent losses of up to 10 per cent. of the population).

Both *Cercospora personata* (B & C) E & E. and *C. arachidicola* Hori cause leaf-spots of groundnuts at Nachingwea. Serious infections result in heavy defoliation and premature death of the crop, thus rendering mechanised harvesting operations more difficult. Detailed studies were made of the pattern of incidence of the disease, and the modes of persistence through the dry season at Nachingwea. The epidemic cycle originates from post-harvest volunteer plants of the variety Natal Common, whose seed has no dormancy period, and from viable inoculum in crop residues and in the soil. An early build up of infection takes place on volunteer plants from seed germinating with the first rains. Measures for the control of these infection-sources have been formulated. A number of varieties have been found to have some degree of resistance: these all have dark green foliage, which is usually associated with spreading habit and a longer growing period. The varieties Kanyoma and Mwitunde are both very resistant, and over 300 selections of high-yielding plants of good habit were made for plant-to-row trials. Observations were commenced on the nature of the resistance exhibited by these varieties.

A disease of groundnuts known locally as "wilt" had been observed at Nachingwea in previous years. The symptoms are a partial to complete wilting of the foliage, temporarily recoverable in the early stages, which takes place after the setting of the pods. Complete wilting is followed by termite- and saprophyte-invasion and break-up of the plant. Affected plants occur in small patches, with an apparent tendency for higher incidence on lower-lying soil types.

Internal symptoms are a yellowing of the cortex of the main root, and the production of blind pods, or pods containing seed only partially developed. These "pops" can also be found on plants which have not shown the wilting symptoms. Numerous attempts to isolate some pathogen from the yellowed cortex, or from any other root tissue, have failed. It is considered that the condition may be due to deficiency of some element; in other parts of the world "pops" are produced under conditions of calcium deficiency. Applications of lime are to be tried as a remedy for the disease.

The attack of *Puccinia polysora* Underw. on the maize crop in 1953 was the first recorded incidence of this rust in South Tanganyika. Infection became very heavy after tasselling, until all the foliage was killed, often well before the normal date of maturity. Selections made of high-yielding, agronomically suitable strains from the native mixture Katumbili included some with apparent tolerance of the infection.

Soil Survey and Management

B. Anderson

The soil survey of the Nachingwea district was continued in the Namanga area, where work had been started in 1952; a map covering about 8 square miles has been produced. One of the relations made evident by this map is the influence on the soil of the underlying rock. A succession of patches of shallow, rather sandy soils lie on a line following the strike of the quartzite outcrop which forms Namanga Hill. These soils belong to the Namatula and Mitumbati series, briefly described in last year's report, and are flanked by heavier soils of the Nachingwea and Nagaga series. In the valleys the line of the quartzite outcrop is obscured by colluvial or alluvial deposits. It is only on the ridges that the nature of the underlying rock has impressed itself on the soil.

The Namanga soil map was followed by one of Chumbati Farm, together with some surrounding woodland, about 10 square miles in all. In this area to the east of Nachingwea the country is less dissected by minor valleys and drainage lines than the areas previously surveyed. Possibly connected with this fact is the comparatively low proportion of sandy soil in the Chumbati Farm area. The Nachingwea and Nagaga sandy loams on the ridges and upper slopes often pass directly into valley clays of the Nkumba series, without any development of the belts of sand on the lower slopes that are a characteristic feature of the Experimental Farm and Namanga areas. The longer, less-dissected slopes of the Chumbati Farm area suggest a less mature topography than that to the west of Nachingwea. There also appears to have been a rejuvenation of the drainage in geologically recent times. The immaturity of the topography will have given the sandy belts less opportunity to develop, while the deepening of the valleys by the intermittent streams will have tended against the deposit of sand along the sides of the valleys. The soil maps were all produced to the scale of 1 in 10,000.

Analysis of the profiles dug during the course of this survey has been the main work of the laboratory during the year. It is hoped to complete it early in 1954. The classification remains that given in last year's report, with the addition of a few minor series occurring under special conditions of topography, parent material, etc.

In fields under crop, there are sometimes very marked differences in plant vigour over distances ranging from five or six yards to several hundred yards. In one case investigated, the poor growth appeared to be due to localised leaching by water running off a hill adjoining the affected field. Two samples, taken from sites only a few yards apart, gave the results shown in Table V.

TABLE V

CROP GROWTH AND ANALYSES ON ADJOINING SITES

Condition of crop (sorghum)	pH (in water)	Exchangeable bases (m.e./100g.)				Citric-soluble P (mg/100g.)
		Ca	Mg	K	Mn	
Stunted	4.4	0.53	0.49	0.11	0.064	0.28
Healthy	5.9	2.68	1.01	0.15	0.034	0.79

In another case, where there was a local area of base-deficient soil, the conditions appeared to be geologically determined. Aerial photographs of the same area, taken before bush-clearing, showed bands of poor growth in the original bush, following the strike of the underlying rock.

To get some idea of the general variability of the soil, four fertiliser experiments, of uniform design and each including four levels of phosphate applied to maize, were laid down on different sections of the Experimental Farm. A soil sample was taken from each plot of all four experiments. On each sample the pH was determined and also the phosphorus extractable by 0.3N hydrochloric acid and by 1 per cent. citric acid.

One of these experiments was sited on a sand (Nailala series) which had been cleared from *miombo* woodland during the preceding dry season. The dominating soil factor proved to be patches of alkaline soil on the sites of fires. (After felling, the trees had been cut up, piled in heaps and burnt). The pH of individual plots ranged from 5.43 to 7.70. On the actual site of a fire, which occupied only a small portion of a plot, the pH must have been much higher; the soil was too alkaline for the maize and remained bare. There was a similar wide variation in extractable-phosphorus figures. Rather unexpectedly, there proved to be a negative correlation between yield of maize and extractable phosphorus, due to the higher levels of the latter being associated with high concentration of alkali from the wood-ash, which in turn reduced the plant population of the plot. The effect of the wood-ash was no doubt aggravated by the light texture of the soil and the abnormally low rainfall in the first two months of the 1952/53 rainy season (about half of normal).

The other three experiments were on red sandy loams of the Nachingwea series. These soils had been cleared two years previously and had been cropped in the preceding year. A much greater uniformity of soil prevailed in these experiments, but odd plots of high pH and phosphorus content still occurred. Thus in one of these experiments fourteen of the plots showed a pH between 4.5 and 5.5 (and citric-soluble phosphorus between 0.22 and 0.70 m. per 100 g. soil). The remaining two plots showed pH values of 5.8 and 6.9 (citric-soluble phosphorus 0.74 and 2.28 mg. per 100g., respectively). These high values are probably the result of residual wood-ash, but a certain amount of soil variability is due to the presence of termitaria. On these soils the termites build largely underground and the termitaria are not easily recognisable after the field has been ploughed. Statistical analysis of the plot yields and analytical figures showed no correlation in any of these experiments between yield and pH or yield and extractable phosphorus, in spite of the fairly wide range of pH and phosphorus. Two out of the three experiments showed a high correlation between pH and extractable phosphorus.

The results of the four experiments are summarised in Table VI. The yield figures for sites 2 and 3 are adjusted for population differences. The pH values were determined in M/100 $CaCl_2$, which gives values about 0.75 lower than distilled water. All plots in the experiments received a standard top-dressing of sulphate of ammonia.

TABLE VI

SUMMARY OF FERTILISER EXPERIMENTS AT NACHINGWEA IN 1953

Soil	Nachingwea sandy loam			Nailala sand
Site	1	2	4	3
pH (mean of all plots)	5.2	5.1	5.7	6.3
Citric-soluble P, mg./100 g. (mean of all plots)	0.57	0.55	0.22	1.69
O.3N HCl-soluble P, mg./100 g. (mean of all plots)	0.18	0.31	0.12	0.98
Yield without fertiliser (lb./acre grain)	1442	1843	2492	2377
Response to 50 lb./acre triple superphosphate	715*	-111	237	463**
Response to 100 lb./acre triple superphosphate	972**	15	362	473**

* Significantly different from nil at 5 per cent. level.

** Significantly different from nil at 1 per cent. level.

These experiments do not suggest that either pH or phosphorus extractable by citric acid or dilute hydrochloric acid will be of much value in predicting yields or response to fertiliser. This work will be continued.

In many areas of poor growth on the production fields, a marked improvement in the condition of the crop coincided with the sites where the cleared bush had been burnt. (A harmful excess of ash, such as was found on the Nailala sand on the Experimental Farm, is exceptional.) This well-known effect is still not entirely explained. In one case investigated, where there appeared to be no deficiency of bases in the field in general, the beneficial effect on the site of the fire was ascribed to better penetration of the few showers of rain which fell in the very dry early part of the growing season; but increase in plant-available phosphate may have been the explanation. Ammonium- and nitrate-nitrogen were very little higher on the sites of fires than on the rest of the field.

Among minor investigations was a comparison of different methods of phosphate extraction. "Available phosphate" by citric and dilute hydrochloric acid extractions was compared with "total phosphate", obtained by refluxing with concentrated hydrochloric acid. For both Kongwa and Nachingwea soils (usually the sample was of the top six inches) the total phosphate was about thirty times that extracted by 1 per cent. citric acid (see table below). The "total phosphorus" figure of approximately 12 mg. P per 100 g. of soil is low by temperate region standards. It is in fact about equal to the citric-soluble phosphorus in a reasonably good English arable soil (Table VII).

TABLE VII

AVAILABLE AND TOTAL PHOSPHATE

Place	No. of samples	Mean values of extracted P, mg./100 g.		
		1% citric	0.3N HCl	conc. HCl
Kongwa	4	0.38	0.16	13.5
Nachingwea	13	0.48	0.41	12.4

Soil nitrogen, nitrification and the physical structure of the soil are other aspects of the Nachingwea soils urgently in need of investigation. Little more than a trial of methods of analysis was possible during the year. It is hoped to find time for more in the future.

APPENDICES

Meteorological Observations, Muguga 1953

Owing to the delays in the arrival of equipment, 1953 was the first full year of operation of the meteorological station at Muguga. The annual summary presented here is the first of a series. When a few years' data have been accumulated it will be possible to compare each current year's figures with the averages.

SUMMARY OF METEOROLOGICAL OBSERVATIONS AT MUGUGA 1953

	Rainfall	Air Temperature			Air Humidity	Windspeed	Sunshine	Open Water Evaporation	
	Monthly totals	Monthly means of daily values			% R.H. from means of V.P. at 0830 and 1600 hrs.	Mean wind-speed 6 ft. above ground	Mean daily sunshine-hours	Sunken pan insulated from soil	Raised pan with heavy grid cover
	inches	Max.	Min.	Mean	per cent.	m.p.h.	hours	inches	inches
January	0.52	74.09°F	52.46°F	63.28°F	58.50	9.03	9.79	8.52	—
February	nil	76.55°F	53.17°F	64.86°F	53.17	10.60	10.76	8.81	9.59
March	1.03	75.51°F	55.35°F	65.43°F	64.83	10.38	9.22	8.98	9.46
April	4.61	72.86°F	55.92°F	64.39°F	75.00	6.91	7.53	5.53	5.91
May	6.31	67.85°F	54.24°F	61.04°F	80.67	6.41	6.79	4.28	4.41
June	1.23	69.23°F	49.74°F	59.49°F	75.00	3.68	6.38	3.81	3.69
July	0.30	66.59°F	46.77°F	56.68°F	73.50	5.12	6.77	— *	— *
August	1.12	66.29°F	49.45°F	57.87°F	76.33	5.56	5.05	4.08	4.30
September	0.96	70.44°F	50.49°F	60.47°F	70.50	6.87	7.66	5.83	6.28
October	1.51	71.81°F	52.62°F	62.22°F	68.83	7.50	7.91	6.18	7.03
November	4.16	69.22°F	54.03°F	61.63°F	75.83	8.03	6.12	4.31	5.35
December	0.72	71.70°F	53.14°F	62.42°F	67.00	8.02	9.06	6.12	7.24
Year	22.50							* tanks repainted.	

This data is intended to outline the physical environment of the E.A.A.F.R.O. laboratories and the Experimental Farm, which lie at an altitude of 6,800 feet and near to the east edge of the Rift Valley. The latter greatly influences the local climate, which is considerably drier than that of districts lying further to the east at the same altitude. The meteorological enclosure is sited on a broad open ridge in country of undulating topography with many scattered wattle and eucalyptus plantations. Except for its better grass cover, this site is typical of the surrounding countryside of the Kikuyu Reserve.

Data of various additional measurements in agricultural climatology, such as solar radiation, soil temperatures, rainfall intensities, duration of dewpoint, windspeed near to the ground and evaporation from open water surfaces in other types of tank, are available for reference in the E.A.A.F.R.O. library.

The weather of 1953 was abnormally dry. The short rains and long rains were both poor. The latter gave 11 inches over April and May, but the distribution was bad, and practically the whole of the 6 inches for May was received in the first few days of the month.

Methods of measurement for the observations summarised in the Table

The rainfall is collected by a standard 5 inch-diameter gauge, checked by an autographic gauge. Air temperatures are taken in a standard Stevenson screen, the thermometer readings being checked by a thermograph. Air humidity is from the standard wet and dry bulbs in the screen, checked daily by an Assman psychrometer, by a hair hygrograph and by recording wet and dry bulb thermometers. Run of wind is estimated by standard Robinson anemometers. Sunshine hours are recorded by a Campbell-Stokes instrument. The evaporation data are from standard United States Weather Bureau (Type A) pans of 4 feet diameter. The sunken pan is supported on a timber grillage in a shallow well, with the water surface at ground level. The pan is insulated from the soil by a 2 inch air gap which is closed at the soil surface. The exposed pan is the standard equipment used by the Kenya Public Works Department. The pan is raised a foot above ground level on a timber grillage, and is covered by a half-inch mesh of stout wire.

Library

Staff

L. D. Verdcourt ..... *Librarian*

During 1953 the work of the Library has continued satisfactorily with routine activities such as the despatch of the Annual Report, loan of library material and the binding and repair of books and journals. In a library of this size, such routine work of maintaining the books in good order and the search for information naturally takes up most of the Librarian's time, but some progress has been made in the long-term jobs which are so necessary. Some of this

work, namely cataloguing old un-indexed material is carried forward year by year; other work, such as the distribution of duplicate periodicals, which was started last year, has been virtually completed during 1953.

In consultation with the Director and the Maintenance Superintendent the new library furniture was planned. It is being made in the E.A.A.F.R.O. workshops and was mostly completed by the end of the year. The periodical racks are especially welcome to users of the library, as the old tables were crowded and it was difficult to pick out the required journal.

The binding of books for the East African Veterinary Research Organisation was started, and 191 volumes were completed, in addition to 920 books and over a hundred pamphlet-boxes for E.A.A.F.R.O., only one extra assistant being employed. This represents a steady output of nearly 16 books per man per month.

Publications

A List of Scientific Papers from the East African Agriculture and Forestry Research Organisation for 1953

A limited number of offprints of the following papers is available. Application should be made to the Librarian.

Birch, H. F. (1953) Phosphate response, base saturation and silica relationships in acid soils. *J. agric. Sci.*, **43,** 229-235.

Birch, H. F. (1953) The relationship in acid soils between base saturation and phosphorus uptake by grasses. *J. agric. Sci.*, **43,** 275-280.

Carey, T. M. and P. Robinson (1953) The manuring of sugar-cane. *Emp. J. exp. Agric.*, **21,** 99-115.

Duthie, D. W. (1953) Fertilizer responses in East Africa. *Nature, Lond.*, **172,** 564-566.

Eastop, V. F. (1953) New East African aphids. *Ent. mon. Mag.*, **89,** 199-203.

Eastop, V. F. (1953) Notes on East African aphids. I. Synonomy. *E. Afr. agric. J.*, **18,** 133-135.

Eastop, V. F. (1953) Notes on East African aphids. II. Polyphagous species. *E. Afr. agric. J.*, **18,** 184-187.

Eastop, V. F. (1953) Notes on East African aphids. III. Aphids of cruciferous crops. *E. Afr. agric. J.*, **19,** 14.

Eastop, V. F. (1953) Notes on East African aphids. IV. Aphids of leguminous crops. *E. Afr. agric. J.*, **19,** 104.

Gardner, J. C. M. and J. O. Evans (1953) Notes on *Oemida gahani* Distant (Cerambycidae). *E. Afr. agric. J.*, **18,** 176-183.

Glover, J. (1953) The nutrition of maize in sand culture. I. The balance of nutrition with particular reference to the level of supply of nitrogen and phosphorus. *J. agric. Sci.*, **43,** 154-159.

Glover, J. (1953) The nutrition of maize in sand culture. II. The uptake of nitrogen and phosphorus and its relevance to plant analysis. *J. agric. Sci.*, **43,** 160-165.

Glover, J. and P. Robinson (1953) A simple method of assessing the reliability of rainfall. *J. agric. Sci.*, **43,** 275-280.

Glover, J. and P. Robinson (1953) A simple method of calculating the reliability of rainfall. *E. Afr. agric. J.*, **19,** 11-13.

Greenway, P. J., G. B. Wallace, M. M. Wallace and E. V. R. Khomo (1953) The pawpaw, its botany, cultivation, diseases and chemistry. *Tanganyika Dep. Agric., Pamphl.* No. 52.

Griffith, A. L. (1953) Forest nursery course, Muguga, 1952. *E. Afr. agric. J.*, **18,** 118.

Griffith, A. L. (1953) Forest research and education. The East African Agriculture and Forestry Research Organisation. *Proc. Sixth Brit. Commonw. For. Conf., Canada.*

Griffith, A. L. (1953) Forest research in East Africa. *Proc. Nairobi sci. phil. Soc.*, **6,** 17-22.

Griffith, A. L. (1953) The sixth British Commonwealth Forestry Conference. *E. Afr. agric. J.*, **18,** 116-117.

Griffith, A. L. (1953) Statistical methods in forest research. Strip enumeration surveys. *Proc. Sixth Brit. Commonw. For. Conf., Canada.*

Harris, W. V. (1953) A new termite from the Belgian Congo. *Rev. zool. Bot. Afr.*, **47,** 261-2.

Harris, W. V. (1953) A note on fungus growing by termites. *Proc. R. ent. Soc. Lond.*, C, **18,** 20.

Harris, W. V. (1953) A note on the termites from St. Helena. *Proc. R. ent. Soc. Lond.*, A, **28,** 13-14.

Hursh, C. R. and H. C. Pereira (1953) Field moisture balance in the Shimba Hills, Kenya. *E. Afr. agric. J.*, **18,** 139-145.

KEEN, B. A., DUTHIE, D. W. *et. al.* (1953) Crop responses to fertilizers and manures in East Africa (Report of a conference of the Specialist Committee on Soil Fertility). *E. Afr. agric. J.*, **19,** 19-57.

MCKINLAY, K. S. (1953) Use of repellents to simplify insecticide field trials. *Nature, Lond.*, **171,** 658.

NUTMAN, F. J. (1953) Notes on the relationship between climatic factors and transpiration and assimilation of *Eugenia aromatica*. *Ann. Bot., Lond.*, **17,** 611-614.

NUTMAN, F. J. and F. M. ROBERTS (1953) Acute die-back of clove trees in the Zanzibar Protectorate. *Ann. appl. Biol.*, **39,** 599-608.

NUTMAN, F. J. and F. M. ROBERTS (1953) Investigations into diseases of the Clove tree in Zanzibar. *E. Afr. agric. J.*, **18,** 146-154.

NUTMAN, F. J. and F. M. ROBERTS (1953) Sudden death disease of the Clove tree, *Eugenia aromatica*. *Nature, Lond.*, **171,** 128.

NUTMAN, F. J. and F. M. ROBERTS (1953) Two new species of fungi on clove trees in the Zanzibar Protectorate. *Trans. Brit. mycol. Soc.*, **36,** 229-234.

PEREIRA, H. C. and V. R. S. BECKLEY (1953) Grass establishment on eroded soil in a semi-arid African reserve. *Emp. J. exp. Agric.*, **21,** 1-14.

RUDD JONES, D. (1953) Studies on a canker disease of cypresses in East Africa, caused by *Monochaetia unicornis* (Cooke and Ellis) Sacc. I. Observations on the pathology, spread and possible origins of the disease. *Ann. appl. Biol.*, **40,** 323-343.

SHEFFIELD, F. M. L. (1953) Virus diseases of sweet potatoes in parts of Africa. *Emp. J. exp. Agric.*, **21,** 184-189.

VERDCOURT, B. (1952) The family Endodontidae in E. Africa. *Basteria*, **16,** 60-63.

VERDCOURT, B. (1953) Contributions to 'Tropical African Plants', *Kew. Bull.*, **1953,** 89-120.

VERDCOURT, B. (1953) Five new species of *Gulella* from the Usambaras (Notes on snails of N.E. Tanganyika Territory, Part 6) *Proc. malac. Soc. Lond.*, **30,** 36-9.

VERDCOURT, B. (1953) Mudworts in Kenya. *J. E. Afr. nat. Hist. Soc.*, **22,** 65-66.

VERDCOURT, B. (1953) Notes on East African *Gulellae*. *Basteria*, **17,** 36-42.

Verdcourt, B. (1953) Notes on Kenya land and freshwater snails. 4. A note on the distribution of the subgenus *Psichion* of *Trachycystis*. *Basteria*, **17**, 16.

Verdcourt, B. (1953) Observations on the ecology of the land and freshwater mollusca of North East Tanganyika. *Tanganyika Notes and Records*, **33**, 67-82.

Verdcourt, B. (1953) the occurrence of a species of caddis fly *Helicopsyche* Bremi (Trichoptera, Sericostomatidae) in Tropical Africa. *Ent. mon. Mag.*, **89**, 106.

Verdcourt, B. (1953) A revision of certain African genera of herbaceous Rubiaceae. II. The genus *Otomeria* Benth., and the new genus *Batopedina* Verdcourt. III. The genus *Virectaria* Brem., IV. Notes on the genera *Parapentas* Brem., *Tapinopentas* Brem., *Otiophora* Zucc. *Bull. Jard. bot. Brux.*, **23**, 5-64.

Verdcourt, B. (1953) The study of snails and slugs in East Africa. *J. E. Afr. nat. Hist. Soc.*, **22**, 52-56.

Verdcourt, B. and H. Watson (1953) The two British species of *Carychium*. *J. Conch.*, **23**, 306-324.

Way, M. J., (1953) The relationship between certain ant species with particular reference to biological control of the Coreid, *Theraptus* sp. *Bull. ent. Res.*, **44**, 669-691.

Way, M. J. (1953) Studies on *Theraptus* sp. (Coreidae): the cause of gumming disease of coconuts in East Africa. *Bull ent. Res.*, **44**, 657-667.

E.A. Agricultural Journal

Staff

D. W. Duthie ..... *Editor*

M. Y. Robinson ..... *Assistant to Editor*

During the first half of 1953, some difficulty was experienced in obtaining sufficient material for publication: this may have resulted from last year's delays in publication and doubts about the future of the Journal, which were discussed in the Report for 1952. Latterly, however, the removal of these uncertainties has led to an unusually large number of contributions being received, and if this standard is maintained it may be necessary to publish larger issues. Unfortunately the Government Printer, Kenya, has recently received so much extra Emergency work that delays in printing may be unavoidable in future: but appreciation is due to him and to his staff, who have been most helpful in spite of the fact that their Department is now working 24 hours a day.

Minor fluctuations in the number of subscriptions are bound to occur from year to year, so the figure of 1,275 for 1953 as compared with 1,305 for 1952 cannot be taken as indicating a significant decrease. The fact remains, however, that even with the large European farming community, only 436 subscriptions come from Kenya, and of these only 60 are taken out by Government Departments. In comparison, subscriptions from the Governments of Tanganyika and Uganda are 187 and 126 respectively. It would greatly assist dissemination of the information contained in the Journal, if all technical officers in Kenya had easy access to it. The distribution of official and private subscriptions is shown in the following Table:—

Official	Kenya	Tanganyika	Uganda
Agricultural Department	35	100	99
Veterinary Department	13	15	14
Forest Department	1	35	10
Education Department	nil	29	1
Other Government Departments ...	11	8	2
	60	187	126
Private	376	89	28
Total	436	276	154
Total for East Africa ...		866	
Total other countries ...		409	
Grand Total		1,275	